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Speed / Density Theory and Operation

Speed/Density Theory

All MerCruiser EFI engines operate on the fuel injection strategy called “Speed/Density”. This means that the ECM primarily looks at the engine’s **speed** and the intake manifold’s air **density** in order to calculate the correct amount of fuel to inject.

The engine requires an air/fuel mixture of approximately 14:7 to 1 in the combustion chambers. Since the EFI system doesn’t control air flow, it must determine how much air is flowing through the engine in order to calculate the correct amount of time to fire the fuel injectors. The net result is that there must be 1 part of fuel for every 14.7 parts of air going through the engine.

Since the engine is basically an air pump, we know that an engine is capable of pumping a certain (maximum) amount of air at any specific rpm. The actual amount of air it pumps (at a specific rpm) depends on the density of the air in the intake manifold. The air density (in the intake manifold) will vary depending on rpm, throttle plate position and barometric pressure. If the air density in the intake manifold is known, the actual amount of air flowing through the engine (the “Air Mass” or “Mass Air Flow”) **could** be calculated. This calculated (and the actual) air flow is a repeatable function, meaning that at a specific rpm and a specific manifold absolute pressure reading, the air flow through the engine will always be the same.

However, in the speed/density system we do not actually calculate the actual air flow. Instead, the ECM measures the rpm and the air density, then refers to a programmed “lookup table” in the ECM’s EEPROM. This lookup table will be programmed with the correct fuel injector information for every rpm and density reading. The programming engineer has to come up with these figures, because the ECM is not actually calculating the Mass Air Flow.

The speed-density system depends on the engine being unmodified (from its original production state). If we change the volumetric efficiency of the engine in any manner, the amount of air flow for a given rpm and air density will change, causing the ECM to deliver the incorrect amount of fuel. Any modification to the following components will influence the air flow through the engine, throwing the speed-density system out of calibration.

1. Pistons and combustion chambers (anything that changes the compression ratio).
2. Camshaft changes (effecting the valve timing, lift and duration).
3. Changes to intake and exhaust valve size, as well as “porting and polishing”
4. Installing different intake and/or exhaust manifolds.
5. Installing a different size throttle body and/or flame arrestor.

Mass Air Flow Systems

Mass Air Flow systems actually measure the amount of air (or “Air Mass”) entering the engine, so they generally can compensate for modifications or changes to the air flow through the engine. While these systems are generally considered more accurate, they are generally not as robust (and cost effective) as the speed-density system. Mass Air Flow systems are typically used in automotive applications to meet stringent emissions and fuel economy requirements.

One method of measuring the mass of the air flow into the engine is the “Hot Wire” system. A small wire is stretched across the air intake. An electrical charge is run through the wire (causing it to heat up). As air flows over the wire, it changes the temperature of the wire, which changes its resistance (and the resulting current flow). The ECM can pick up this change in current flow and calculate the amount of air entering the system.

Another method of measuring the mass of the air flow into the engine is the “vane-type” Mass Air Flow sensor. A movable vane is mounted in (protrudes into) the air intake system. The rush of intake air through the sensor causes the vane to be deflected. The deflection is measured and a signal sent to the ECM.

NOTE: *The speed-density system is more than accurate enough for our marine applications. The additional reduction in emissions and the resulting increase in fuel economy (with the Mass Air Flow system) are negligible. But when automotive manufacturers must meet emissions standards, they often have to take small improvements where they can find them.*

Speed/Density Operation

The engine’s RPM is easily determined from the REF HIGH signal on systems with EST ignition, or the timing signal from the Thunderbolt Distributor’s hall-effect sensor on small-block MEFI 3 models.

To determine the density of the air in the intake manifold, we need to know the intake manifold vacuum, which we measure with the MAP (Manifold Absolute Pressure) sensor. It is important to remember that a MAP sensor measures the manifold pressure **above** absolute zero (like a barometer), while a conventional vacuum gauge measures the manifold pressure **below** the **current** atmospheric pressure. The use of the Manifold Absolute Pressure Sensor allows us to compensate for variations in atmospheric pressure due to weather and altitude changes. A conventional vacuum gauge would not provide us with this needed information.

NOTE: *While the temperature of the air does affect its density, not all engines use an IAT (intake air temperature) sensor. If no IAT is present, then the ECM assumes 75 degree Fahrenheit for all density calculations. If an IAT is present, then the ECM can more accurately determine the air’s density. However, the amount of correction the IAT adds is a relatively small amount (approximately 10% maximum change in fuel flow).*

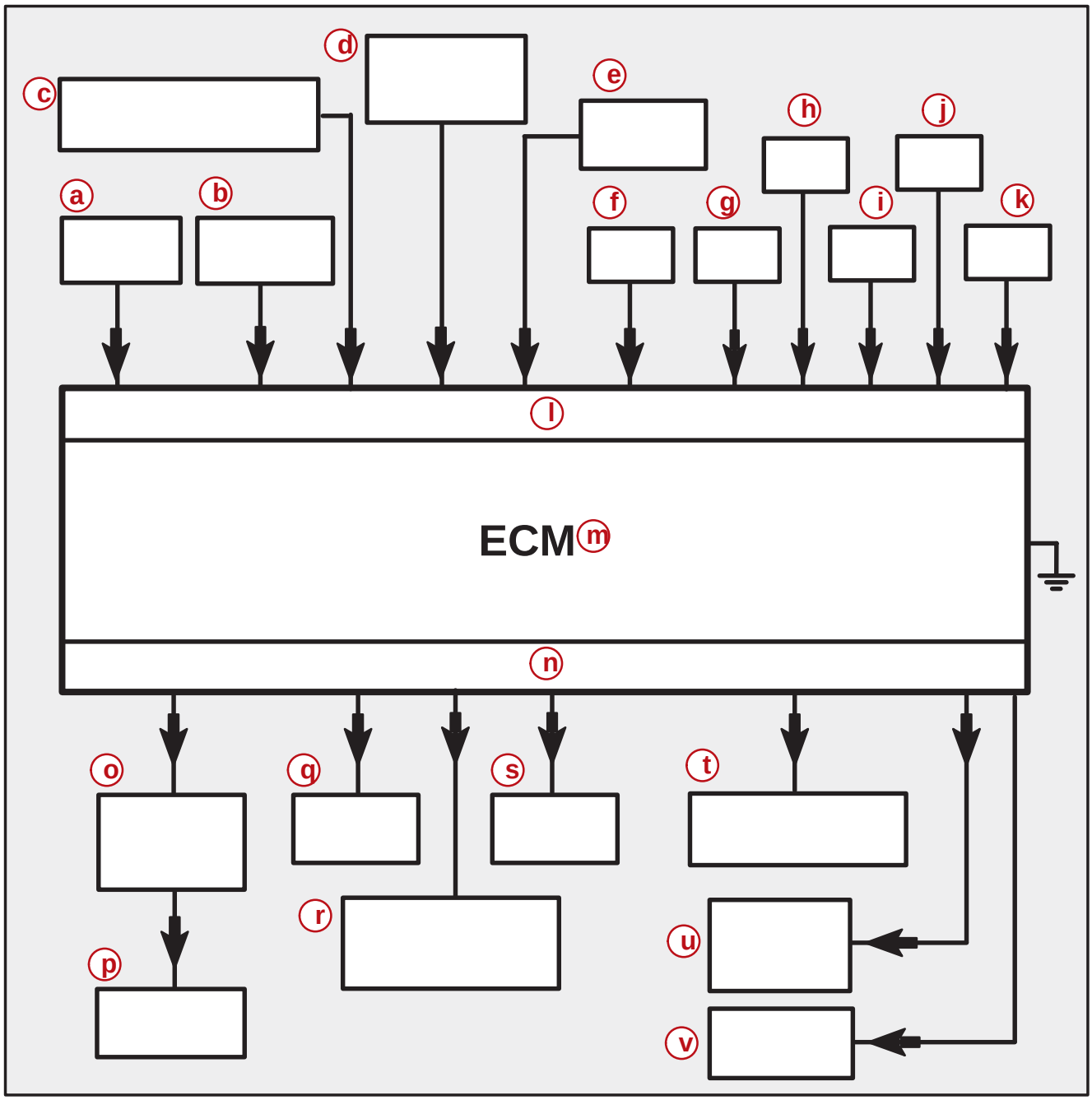
In review, our standard, unmodified production engines flow a repeatable (and therefore “known”) amount of air at any specific engine rpm and manifold pressure. With this knowledge, the ECM can be programmed to deliver the correct amount of fuel from the combination of the speed sensor (distributor signal) and density information (from the MAP sensor).

It is often said that the speed-density system runs “in theory alone”, since the ECM doesn’t really know how much air is flowing through the engine, it is just assuming it knows how much (based on the repeatability of airflow theory). In reality, the system is simple, rugged and works extremely well. But, the ECM cannot compensate for changes in volumetric efficiency of the engine.

Abbreviations

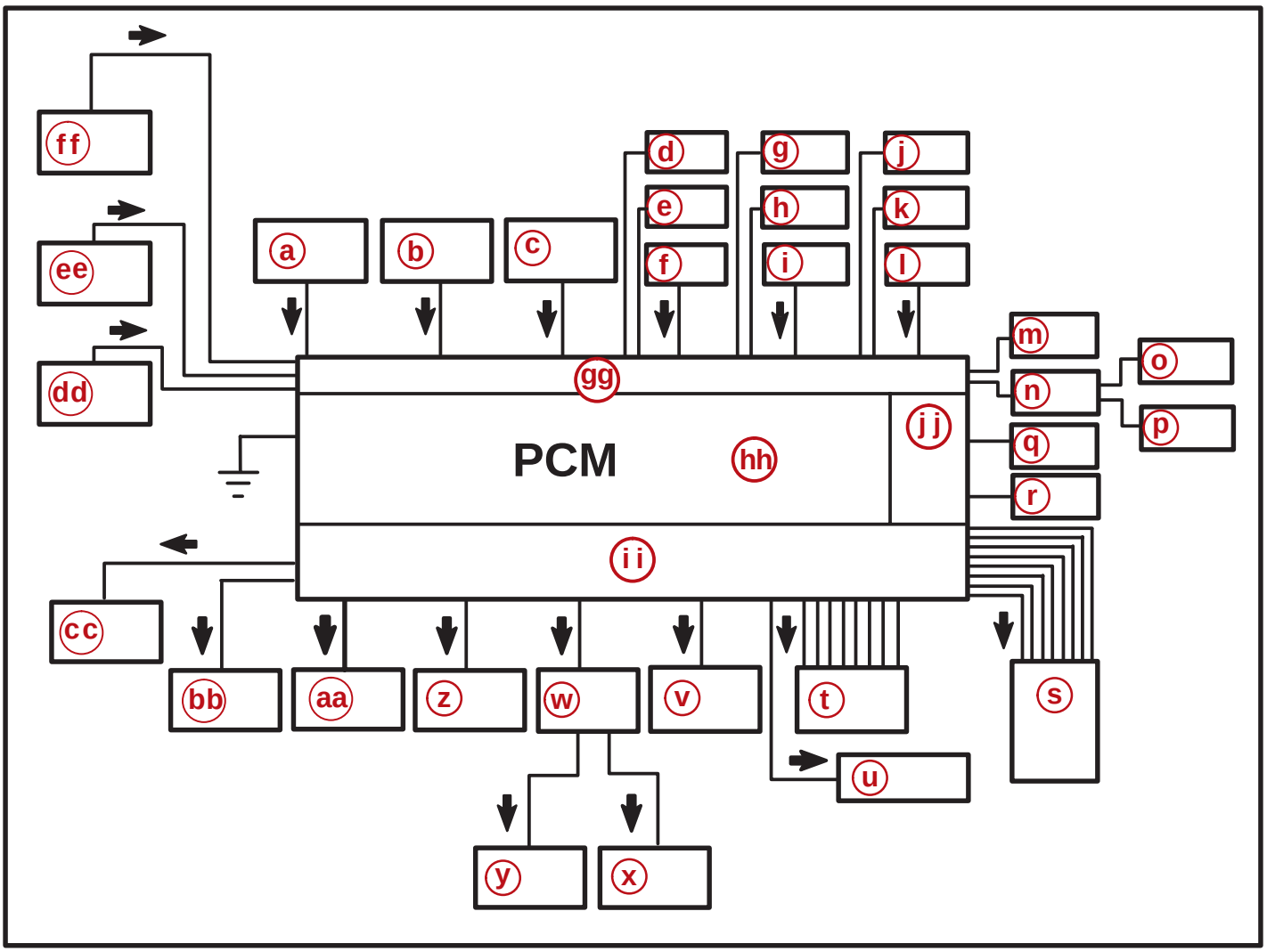
Amp	Amperes	IAC	Idle Air Control
BARO	Barometric Pressure	IAT	Intake Air Temperature
Bat	Battery Positive Terminal, Battery or System Voltage	IC	Ignition Control
B+	Battery Positive	IGN	Ignition
Bps	Beeps	In. hg.	Inches of Mercury
CAM	Camshaft	INJ	Injection
cond	Condition	kPa	Kilopascal
cont	Continuous	KS	Knock Sensor System
Crank	Crankshaft	kV	Kilovolts
CAN	Control Area Network	mA	Milliamperes
CKT	Circuit	MPR	Main Power Relay
CMP	Camshaft Position Sensor	MAP	Manifold Absolute Pressure
Conn	Connector	MAT	Manifold Air Temperature
CPS	Crankshaft Position Sensor	MIL	Malfunction Indicator Lamp
Cyl	Cylinder	mohms	Milliohms
DDT	Digital Diagnostic Tester	mSec	Millisecond
Deg	Degrees	N/C	Normally Closed
Diag	Diagnostic	N/O	Normally Open
DIS	Distributorless Ignition System	PCM	Propulsion Control Module
Dist	Distributor	PROM	Programmable Read Only Memory
DLC	Data Link Connector	RAM	Random Access Memory
DTC	Diagnostic Trouble Code	REF HI	Reference High
DVOM	Digital Volt Ohm Meter	REF LO	Reference Low
DMM	Digital Multimeter	ROM	Read Only Memory
DMT	Digital Multimeter & Tachometer	SLV	Slave
ECM	Engine Control Module	SW	Switch
ECT	Engine Coolant Temperature	TACH	Tachometer
EEPROM	Electronically Erasable Programmable Read Only Memory	Term	Terminal
EFI	Electronic Fuel Injection	TPS	Throttle Position Sensor
EMCT	Exhaust Manifold Coolant Temperature	V	Volts
EMI	Electromagnetic Interference	Vac	Vacuum
ERC	Electronic Remote Control	WOT	Wide Open Throttle
ESC	Electronic Shift Control		
ETC	Electronic Throttle Control		
GND	Ground		
HEI	High Energy Ignition		
HVS	High Voltage Switch		

MEFI 3 ECM Input and Sensor Descriptions



1. - Audio Warning Horn (Buzzer)
2. - Discrete Switches (Audio Warning)
3. - Dist. For Ref. RPM
4. - ECT
5. - FP
6. - Fuel Injectors
7. - Fuel Pump
8. - Fuel Pump Relay
9. - IAC Motor
10. - IAT
11. - Ignition Control
12. - Inputs
13. - Knock Sensor 1
14. - Knock Sensor 2 (7.4L–L29)
15. - Load Sw.
16. - MAP
17. - Outputs
18. - Serial Data (DLC)
19. - System Relay
20. - TP
21. - V-Reference (5-V Output to Sensors)

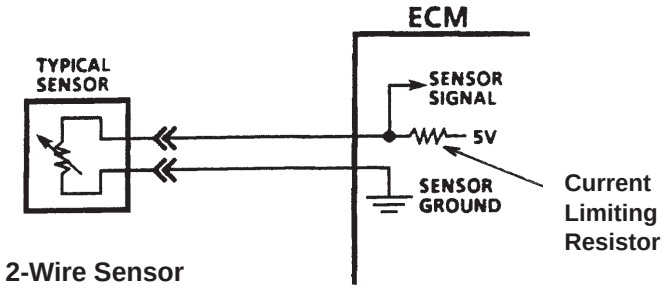
PCM 555/03 Input and Sensor Descriptions



1. - Boost Fuel Pump
2. - Cam Position Sensor (CMP)
3. - CAN Line
4. - Cool Fuel Pump
5. - Crank Position Sensor (CPS)
6. - DLC
7. - ECT
8. - Fuel Injectors 1 – 8
9. - Fuel Level
10. - Fuel Pump Relay
11. - IAC
12. - Ignition Coils 1 – 8
13. - Inputs
14. - Input/Output
15. - Key B+
16. - Knock 1
17. - Knock 2
18. - Lube Oil Bottle
19. - Main Power Relay (MPR)
20. - MAP
21. - MAT
22. - Oil Pressure
23. - Outputs
24. - Paddle Wheel/Sea Temp
25. - Pitot
26. - Port EMCT
27. - Sea Pump
28. - Starboard EMCT
29. - Steering Angle
30. - Tabs
31. - Tach Signal
32. - TP
33. - Transom Harness
34. - Trim UP Relay
35. - Warning Horn

Two-Wire Sensors (ECT and IAT)

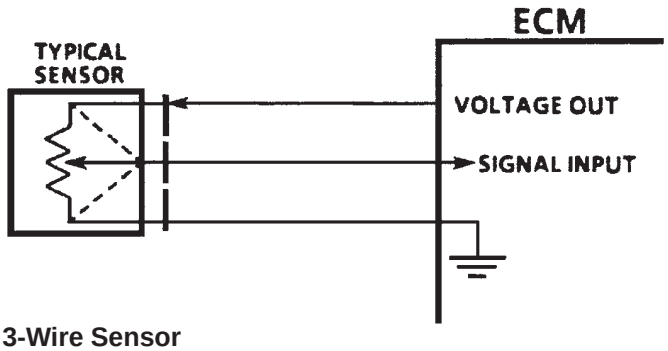
The following figure is the schematic of a 2-wire type sensor. This sensor is basically a variable resistor in series with a fixed-known resistor within the computer. By knowing the values of the input voltage and the voltage drop across the known resistor, the value of the variable resistor can be determined. The variable resistors that are commonly used are called thermistors. A thermistor's resistance varies inversely with temperature.



2-Wire Sensor

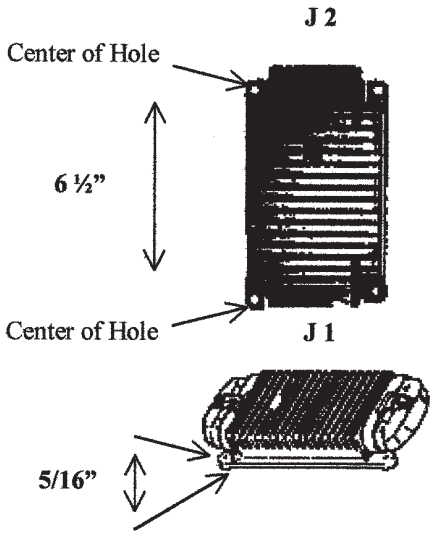
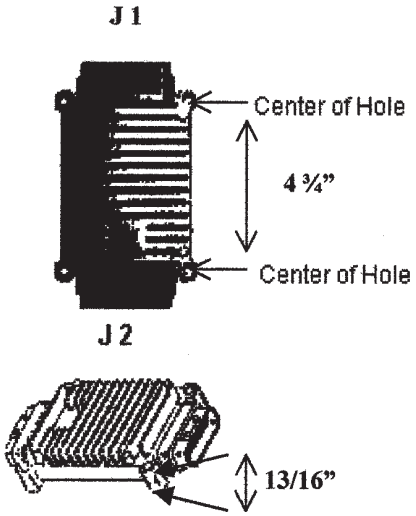
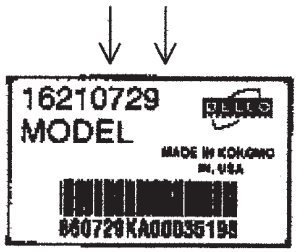
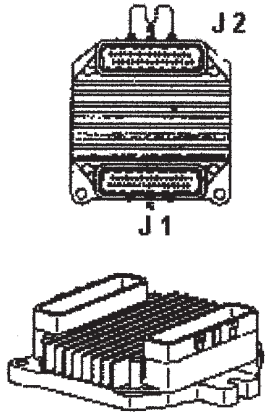
Three-Wire Sensors (MAP, TP and FP)

The following figure shows a schematic representation of a 3-wire sensor. All 3-wire sensors have a reference voltage, a ground and a variable "wiper." The lead coming off of the wiper will be the signal to the Engine Control Module (ECM). As this wiper position changes, the signal voltage returned to the computer also changes.



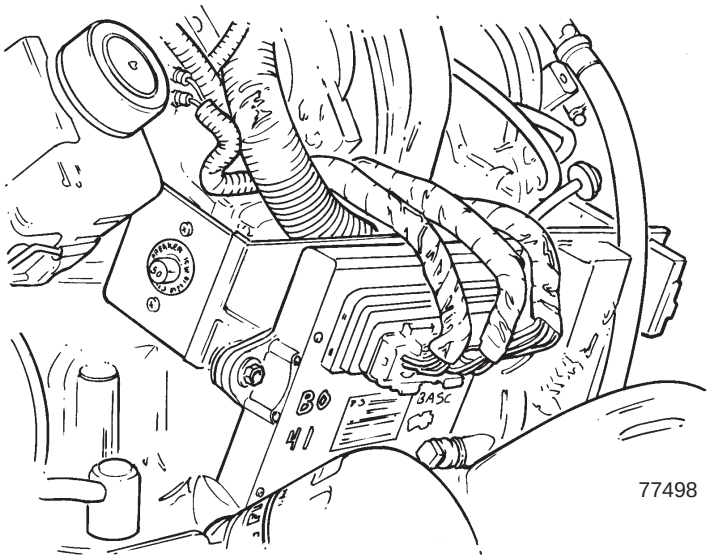
3-Wire Sensor

G.M. E. C. M. Identification

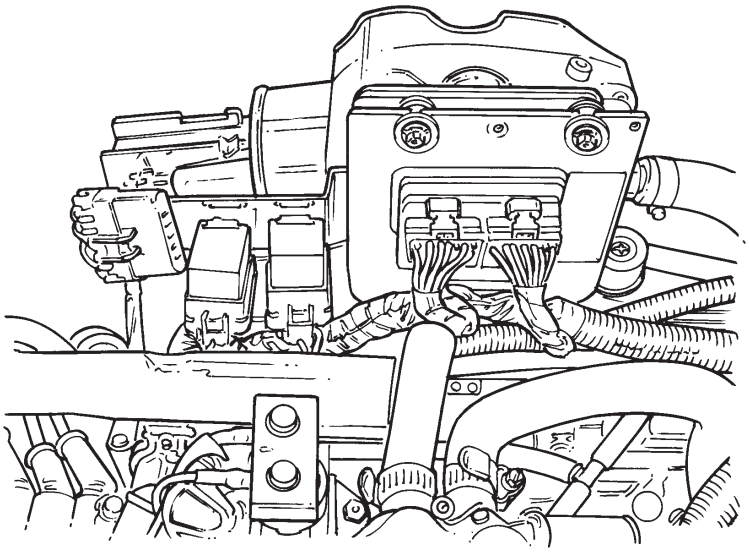
MEFI ____Controller	MEFI _____Controller	MEFI ____Controller
 Original GM Marine E C M Housing *All ECM's have power reduction	 New (Small) GM Marine E C M Housing 	 *Delphi ECM number 16236999 have floating desired idle speed *Delphi ECM number 16237009 don't have floating desired idle speed

ECM 555 and PCM 555/03 Identification

A.

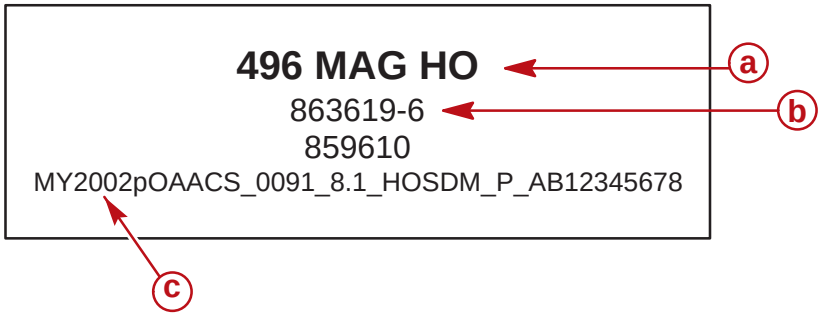


B.



Identify the controllers above: A._____ B._____

Typical ECM / PCM Calibration Label



a - Engine Model
b - Calibration Part Number
c - Model Year

Factors Determining Fuel Injector Pulse Width

NOTE: *The charts below are shown as examples only and represent no particular engine or ECM.*

MAP & RPM vs Injector on Time (Base Pulse Width [BPW])					
MAP (kPa)	**BPW in mSec**				
100	6	7	8	9	10.5
90	5.5	6.5	7.5	8.5	10
80	4	6	7	8	8
70	3.5	5.5	6.5	7.5	8.5
60	3	5	6	7	8
50	2.75	4.5	5.5	6.5	7
40	2.5	4	5	6	6.5
30	2.23	3.5	4.5	5.5	6
20	2	3	4	5	5
RPM	**1000**	**2000**	**3000**	**4000**	**5000**

Base Pulse Width Multipliers	
Water Temp Deg F	**Multiplier**
0	2.50
50	2.00
100	1.50
150	1.00

Throttle %	**Multiplier**
25	1.50
50	2.00
75	2.50
100	3.00

Air Temp Deg F	**Multiplier**
0	1.10
50	1.05
100	1.00
150	1.00

GM EFI ECM COMPARISON and Code Listing

MEFI 1 (93-95 models)	MEFI 1 (96-98 models)[1]	MEFI 2 (98' 350 Mag & L29)	MEFI 3 (99 & newer models)
GM 93 software	GM 93 (MEFI 1) software in a MEFI 2 case[2]	GM 96 software in a MEFI 2 case GM part #16210729	GM 98(or 99) software
Largest ECM (93-95) 4 short mounting bolts J1/J2 on opposing ends of case Same pin locations as MEFI 2	Medium size ECM (96-98)[1] 4 long mounting bolts J1/J2 on opposing ends of case Same pin locations as MEFI 2	Medium size ECM 4 long mounting bolts J1/J2 on opposing ends of case Same pin locations as MEFI 1	Smallest ECM (square) 3 short mounting bolts J1/J2 parallel to each other. Unique pin assignments
Power reduction mode active	Power reduction is NOT active	Power reduction is NOT active	Power reduction is not active
Must manually advance throttle prior to base timing (service mode)	Must manually advance throttle prior to base timing (service mode)	ECM automatically sets rpm during base timing (service mode)	ECM automatically sets rpm during base timing (service mode)
Delco EST Ignition Separate knock module (SB 94-12)	Delco EST Ignition Separate knock module	Delco EST Ignition Separate knock module	EST (Big Block), T-bolt (Small Block)[4] Integral knock module (2 channels)
Clear flood mode active even when the engine is not being cranked	Clear flood mode active even when the engine is not being cranked	Clear flood mode active even when the engine is not being cranked	Clear flood mode is only active when the engine is being cranked
Shift interrupt switch opens the white "IC" line (no spark).	Shift interrupt switch opens the white "IC" line (no spark).	Shift interrupt switch opens ECM J1-19 (retards timing/closes IAC)	Shift interrupt switch opens ECM J2-9 (retards timing/closes IAC)
VST fuel system	VST or Cool Fuel System[3] MPI Cool Fuel models require "fuel rail buffering".	Cool Fuel System "Fuel rail buffering" required	Cool Fuel System / IAT added on TBI units Staggered injector firing eliminates need for "fuel rail buffering"
7 **possible** codes Technician must differentiate between "active" & "logged" codes	7 **possible** codes Technician must differentiate between "active" & "logged" codes	15 **possible** codes Technician must differentiate between "active" & "logged" codes	23 **possible** codes Scan tool (DDT) differentiates between "active" & "logged" codes

MEFI 3 Advanced Features:

Warning system: Low oil pressure, high water temperature and low drive oil level (general warning 1) **or** high transmission temperature (general warning 2) cause a continuous horn on all models. However, certain ECM's will sound the horn in one of two modes ("soft" alarm [1 second on, 3 seconds off] below 3000 rpm and a "hard" alarm [constant horn] above 3000 rpm) when an "Active" code is detected, when battery voltage is below 9v (at the ECM) for at least 5 seconds) and when fuel pressure is too low for 5 seconds (on small block models only). Refer to Service Bulletin 99-3 (revised 12/99) for specific serial numbers and ECM checksum numbers (these additional features are being disabled in current production engines).

The ECM incorporates an integral ignition module (coil driver circuit). This is only used on the small block V6 & V8 models (except Scorpion models). A standard "thunderbolt" distributor and ignition coil are used, but the ECM controls ignition coil dwell and timing. This integral module is not used on big block models.

ECMs with GM part #1623999 will incorporate a "Moving Desired Idle mode" that operates between 0% and 5% Throttle plate opening. This will allow more consistent speeds at part throttle operation since the ECM will attempt to maintain a steady rpm within this range.

Inboard applications have a "Load Anticipation Mode". Additional IAC counts are added when in either gear and are removed when in Neutral. A neutral safety type switch is connected to ECM J2-20. It is normally closed (grounded) in Neutral and is open (ungrounded) in either gear.

The MEFI 3 ECM incorporates Password protected EEPROM to prevent unauthorized reprogramming.

Footnotes:

1. Except the 1998 350 Magnum MPI and the L29 (7.4L MPI).
2. If GM part number is any number other than #16210729, it is MEFI 1 software in a MEFI 2 case. Only #16210729 is true MEFI 2.
3. 1996 models are all VST, 1997 was a transition year, 1998 models are all Cool Fuel.
4. Scorpion models use EST ignition, all other small blocks use the Thunderbolt hybrid ignition.

GM EFI ECM COMPARISON and Code Listing

MEFI 1 (GM 93 Software)		MEFI 2 (GM 96 Software)		MEFI 3 (GM 98/99 Software)	
				13	Oxygen sensor inactive[5]
14	ECT HIGH or LOW (open or short)	14	ECT voltage HIGH (open)	14	ECT voltage HIGH (open)
		15	ECT voltage LOW (short)	15	ECT voltage LOW (short)
21	TPS HIGH or LOW (short or open)	21	TPS voltage HIGH[1]	21	TPS voltage HIGH[1]
		22	TPS voltage LOW[2 or 8]	22	TPS voltage LOW[2 or 8]
23	IAT HIGH or LOW (open or short)	23	IAT voltage HIGH (open)	23	IAT voltage HIGH (open)
		24	Speed sensor inactive[5]	24	Speed sensor inactive[5]
		25	IAT voltage LOW (short)	25	IAT voltage LOW (short)
				31	Governor not tracking[5]
				32	EGR valve not tracking[5]
33	MAP HIGH or LOW (short or open)	33	MAP voltage HIGH[1]	33	MAP voltage HIGH[1]
		34	MAP voltage LOW[2 or 8]	34	MAP voltage LOW[2 or 8]
		41	Open IC circuit	41	Open IC circuit[6]
42	IC or bypass circuit[3]	42	IC or bypass circuit[4]	42	IC or bypass circuit[4,6]
43	Knock circuit failure	43	Continuous knock detected	43	Continuous knock detected
		44	Cannot detect knock activity	44	Cannot detect knock activity
				45	Ignition coil driver circuit fault[7]
51	Calibration checksum error	51	Calibration checksum error	51	Calibration checksum error
		52	EEPROM failure (in ECM)	52	EEPROM failure (in ECM)
				54	O^2 sensor LEAN[5]
				55	O^2 sensor RICH[5]
				61	Fuel pressure sensor HIGH[7]
				62	Fuel pressure sensor LOW[7]

NOTE: Not every engine will use every possible code, check the service manual for the codes used on a specific engine.

Footnotes:

1. Signal lead shorted to power.
2. Signal lead shorted to ground (or open).
3. Circuit(s) either open or shorted to ground.
4. IC grounded and/or Bypass open or grounded.
5. Not used by MerCruiser at this time.
6. Big block engines only (with Delco EST ignition).
7. Small block engines only (with Thunderbolt distributor and coil).
8. Reference (5V+) open or shorted to ground.

IMPORTANT: On the L29, injector banks are 1,3,5 & 7 and 2,4,6 & 8. All other MPI models should be 1,4,6 & 7 and 2,3,5 & 8

MEFI-3 and Audio Warning

The MEFI-3 engine's Audio Warning system will sound the alarm differently and it has more items that will cause it to sound.

There is what is called a 'soft' and a 'hard' alarm.

1. Soft Alarm = Below 3000 rpm. Horn on for 1 second, off for 3 seconds, on for 1 second, off for 3 seconds, etc.
2. Hard Alarm = Above 3000 rpm. Horn sounds all the time.

Audio alarm sounds for the same malfunctions as MEFI-1 and -2;

1. ▲MCM - Low lube level in Gear Lube Bottle. [General 1] or MIE - High Transmission fluid temperature [General 2].
2. MCM/MIE - Low engine oil pressure.
3. MCM/MIE - Too high engine coolant temperature.

▲Early production and service ECMs had the following items that will sound the alarm;

1. MCM/MIE – Horn will sound if there is an active engine Diagnostic Trouble Code [DTC] that is occurring while the engine is running. The horn will not sound a stored DTC. Correcting the DTC malfunction will stop the horn.
2. MCM/MIE – Horn will sound if the battery voltage to the ECM is low, [less than 9v for at least 5 seconds]. Using the throttle lever to increase engine rpm to get the alternator to put out more voltage will correct most low voltage problems.
3. MCM/MIE – V6 and V8 305/350 cid engines only. Horn will sound if there is low fuel pressure [for at least 5 seconds]. These engines have a fuel pressure sensor. The EFI engines have the sensor in the throttle body unit and the MPI engines have the sensor located in the port fuel rail toward the rear of the engine. Correcting the cause of the low fuel pressure will stop the horn.

▲The ECM checksums listed below have these additional alarms turned ON in them.

NOTE: Later production and service replacement ECMs have these extra alarms turned off. If the ECM checksum is different from the ones listed below, the extra alarms in that ECM is turned OFF.

MCM 4.3L EFI: ECM never had these extra alarms turned on.

MCM 5.0L EFI: With D04B or D074 checksum.

MCM 5.7L EFI: With D7ED or D798 checksum.

MCM 350 MPI, MCM 350 MPI Horizon, MIE 350 MPI Ski, MIE 350 MPI Inboard or MIE 350 MPI Horizon Inboard: With E60D or EAED checksum.

MIE Black Scorpion: With BB98 or BB42 checksum.

MCM 7.4L MPI or MIE 7.4L MPI Inboard: With FE28.checksum.

MCM 454 MPI, MCM 454 MPI Horizon or MIE 454 MPI Horizon Inboard: With EBC4 checksum.

MCM 502 MPI or MIE 8.2L MPI Inboard: With F02D checksum.

Additional MEFI-3 ECM Features

Moving Desired RPM Mode (ECM's with Delphi #1623999)

A Moving Desired RPM mode has been added to the MEFI-3 ECM. This mode will increase the desired idle rpm to a calibrated set point according to the throttle position. When the Throttle Position (TP) sensor is at the closed throttle setting, the ECM will use Idle Air Control (IAC) and Ignition Control (IC) to maintain the calculated 'desired rpm'. This will make the transition from idle (closed throttle) to higher throttle settings smoother. It will also help maintain constant low engine speeds from 700 to 1200 rpm. At 5% or greater TP sensor setting, the Moving Desired RPM mode is not active.

IMPORTANT: An improperly adjusted throttle cable can cause the engine idle rpm to be higher than the normal 600 rpm even though the control throttle lever is back to the idle rpm position.

Load Anticipation Mode

The Load Anticipation mode is used on MIE inboard and ski engines only. The function is used to help inboard engines during shifting. An electrical signal from the neutral safety switch (on the transmission) goes to the ECM on J2-20. This signal tells the ECM if the switch is closed or open. In neutral gear, the neutral safety switch is closed (signal grounded). When shifting into gear, the switch opens (signal open).

When the transmission is shifted into gear, the open signal causes the ECM to add a calibrated amount of bypass air with the IAC. This is done to increase the load handling capability of the engine when going into gear on larger boats. When shifting back into neutral gear, the additional IAC bypass air is removed in an attempt to limit engine rpm flares. The amount of IAC air used is constantly monitored by the ECM. After the transmission is shifted, and the engine has stabilized, the ECM calculates an 'error band' from the Moving Desired RPM mode and adjusts the Load Anticipation mode IAC count accordingly. This allows the ECM to 'learn' the best IAC bypass air position to use for shifting each particular boat.

NOTE: *The Load Anticipation mode is on MIE 454/502 cid inboard engines also.*

Shift Switch Operation

The Shift Switch is used on Alpha models only. The switch is normally 'closed', completing a circuit from the ECM's J2-9 terminal through the shift switch, to ground. When shifting, the switch will 'open' the J2-9 wire between the ECM and ground. This will cause the ECM to go and lower the IAC motor count and retard the ignition timing to help the shifting. When the shift switch is back in the normal position, ignition timing and IAC motor count are restored.

ECM/PCM 555 Engine Guardian Strategy & Additional Guardian Sensors

Engine Guardian is the focal point of the self-diagnostic strategy of ECM/PCM 555. It helps protect the engine from possible damage that could result from several faulty conditions. The system monitors the sensors incorporated on the engine and if a malfunction is discovered a fault description is stored in the PCM and available power is normally reduced. By ensuring engine output is at a low enough level, the engine is better protected from thermally induced failures.

For example, if an open or short is found in an exhaust manifold sensor, available power will be reduced to 90% of total, the warning horn will sound 2 beeps per minute and the MercMonitor gauge (SC1000) will display a warning lamp. In an exhaust manifold overheat condition the maximum rpm will vary with the temperature of the manifold and could be limited to idle in extreme cases of overheating, a continuous horn will sound and the SC1000 will display a warning lamp.

IMPORTANT: Engine Guardian cannot guarantee that engine damage will not occur when adverse operating conditions are encountered. Engine Guardian is designed to warn the operator of an adverse condition and to reduce power by limiting rpm in an attempt to reduce possible engine damage. The boat operator is ultimately responsible for proper engine operation.

ECM 555 Warning System Operation

The engine warning system incorporates an audio alarm and, if installed, Smartcraft Gauges System. When the key switch is turned to the ON position, the audio alarm will momentarily activate to test the warning system. The alarm should sound once if the system is operable. This table is a guick guide, showing what warning output will accompany a fault.

Fault	Smartcraft Gauges	Audio Alarm	Available Power	Description
ECT CKT HI	Yes	2 Bp/min	90%	Open
ECT CKT LO	Yes	2 Bp/min	90%	Short
ECT Coolant Overheat	Yes	Constant	6 - 100 %	Engine guardian overheat condition
EST 1 Open [1]	Yes	2 Bp/min	100%	Coil harness wire open
EST 1 Short [1]	Yes	2 Bp/min	100%	Coil harness wire short
Fuel Injector 1-7-4-6 Open	Yes	2 Bp/min	100%	Fuel injector wire open
Fuel Injector 3-5-2-8 Open	Yes	2 Bp/min	100%	Fuel injector wire open
Guardian Strategy	Yes	Constant	0% - 100%	Protection Strategy
IAC Output LO/HI [2]	Yes	2 Bp/min	90%	Open
Knock Sensor 1 Lo	Yes	2 Bp/min	90%	Open
Knock Sensor 1 Hi	Yes	2 Bp/min	90%	Short
Low Drive Lube Strategy	Yes	Constant	100%	Low oil in sterndrive
Low Oil Pressure Strategy	Yes	Constant	0 - 100%	Low oil pressure strategy

NOTE: *If any 5v sensor becomes shorted to ground the engine will not start. If the engine is operating when the short occurs the engine may stop operating and will not start.*

NOTE: [1] *GM EFI ignition system failure open or shorted, driver will flag EST 1 fault.*

NOTE: [2] *TPS must see 5% throttle then back to 0% to flag IAC fault.*

NOTE: [3] *2-wire sensor open will read sensor Hi on scan tool.*

NOTE: [4] *VDC PWR Low - if shorted or no voltage engine will not start; if VDC PWR voltage falls velow 22 volts will set sensor faults.*

NOTE: [5] *Shift Switch - will activate code when engine rpm are above 3500 rpm and 40% load.*

ECM 555 Warning System Operation (continued)

Fault	Smartcraft Gauges	Audio Alarm	Available Power	Description
Main Power Relay Output	Yes	No	N/A	Engine will not start
Main Power Relay Backfeed	Yes	No	N/A	Engine will not start
MAP Sensor 1 Input High	Yes	2 Bp/min	90%	High voltage or short
MAP Sensor 1 Input Low	Yes	2 Bp/min	90%	Open, no visual on SC1000
Oil PSI CKT Hi	Yes	2 Bp/min	90%	Open, defaults to 50.7 psi
Oil PSI CKT Lo	Yes	2 Bp/min	90%	Short, defaults to 50.7 psi
Overspeed	Yes	Constant	rpm limit	Engine over rpm limit
Pitot CKT Hi	No	No	100%	Short or high voltage
Pitot CKT Lo	No	No	100%	Open
Sea Pump PSI Lo	Yes	Constant	6-100%	Guardian Strategy
Sea Pump CKT Hi	Yes	2 Bp/min	90%	Open - 0 psi reading
Sea Pump CKT Lo	Yes	2 Bp/min	90%	Voltage high or short
Sea Water Temp	No	No	N/A	Defaults to –31 degrees C
Fuel Level #1	No	No	N/A	Only if turned on
STB EMCT CKT Hi	N/A	N/A	N/A	N/A
STB EMCT CKT Lo	N/A	N/A	N/A	N/A
STB EMCT CKT Overheat	N/A	N/A	N/A	N/A

NOTE: *If any 5v sensor becomes shorted to ground the engine will not start. If the engine is operating when the short occurs the engine may stop operating and will not start.*

NOTE: [1] *GM EFI ignition system failure open or shorted, driver will flag EST 1 fault.*

NOTE: [2] *TPS must see 5% throttle then back to 0% to flag IAC fault.*

NOTE: [3] *2-wire sensor open will read sensor Hi on scan tool.*

NOTE: [4] *VDC PWR Low - if shorted or no voltage engine will not start; if VDC PWR voltage falls velow 22 volts will set sensor faults.*

NOTE: [5] *Shift Switch - will activate code when engine rpm are above 3500 rpm and 40% load.*

ECM 555 Warning System Operation (continued)

Fault	Smartcraft Gauges	Audio Alarm	Available Power	Description
Steer CKT Hi	No	No	100%	Short or high voltage
Steer CKT Lo	No	No	100%	Open
TPS1 CKT or Range Hi	Yes	2 Bp/min	90%	Short or high voltage
TPS1 CKT or Range Lo	Yes	2 Bp/min	90%	Open or low voltage
Trim CKT or Range Hi	Yes	No	100%	Open or high voltage
Trim CKT or Range Lo	Yes	No	100%	Short
5 VDC PWR Low [4]	Yes	2 Bp/min	90%	Short or low - engine may not start
MAT Sensor Hi	Yes	2 Bp/min	90%	Open - default to –32 degrees F
MAT Sensor Lo	Yes	2 Bp/min	90%	Short - default to –32 degrees F
Shift Switch [5]	Yes	2 Bp/min	90%	Open Circuit

NOTE: *If any 5v sensor becomes shorted to ground the engine will not start. If the engine is operating when the short occurs the engine may stop operating and will not start.*

NOTE: ***[1]*** *GM EFI ignition system failure open or shorted, driver will flag EST 1 fault.*

NOTE: ***[2]*** *TPS must see 5% throttle then back to 0% to flag IAC fault.*

NOTE: ***[3]*** *2-wire sensor open will read sensor Hi on scan tool.*

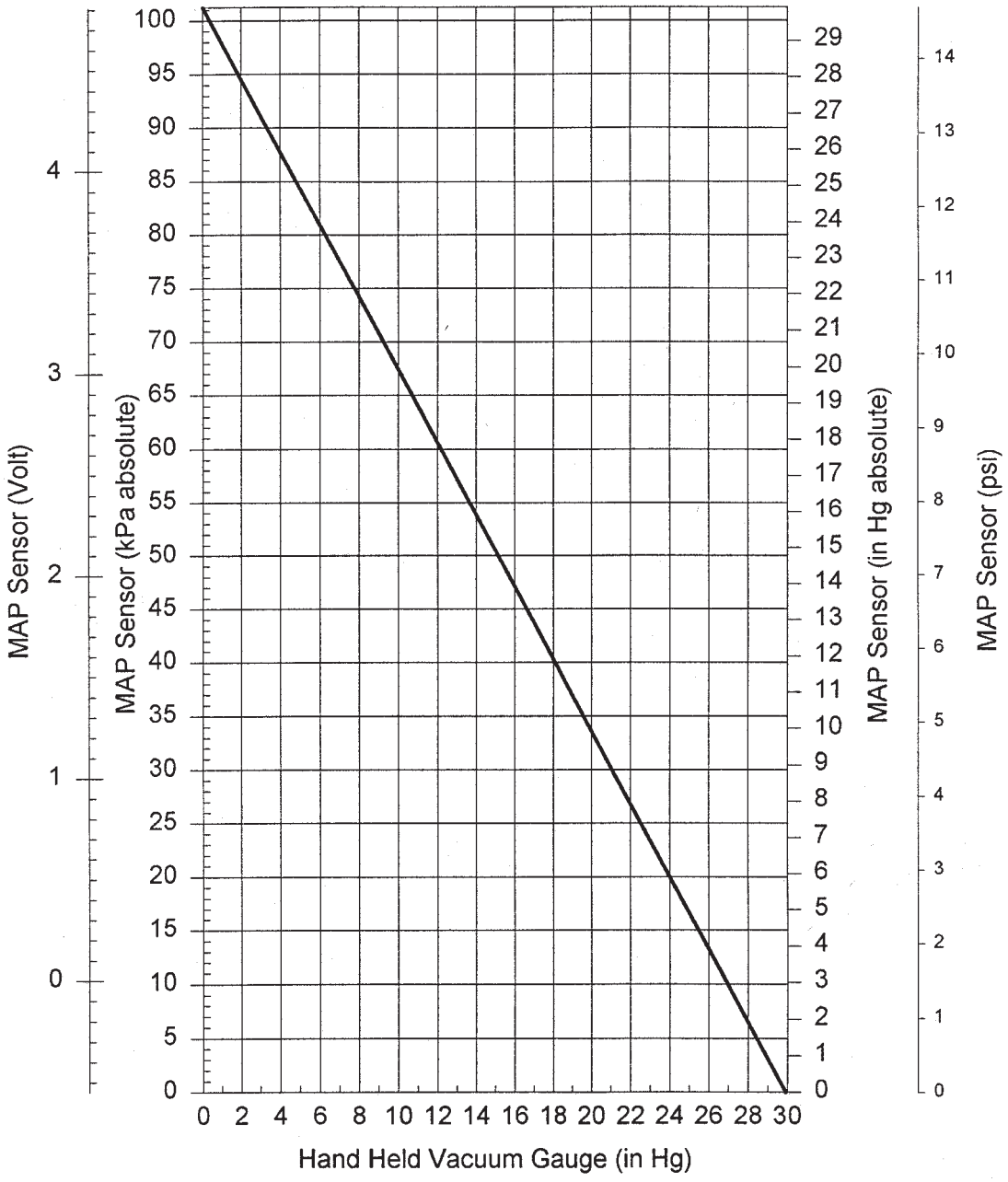
NOTE: ***[4]*** *VDC PWR Low - if shorted or no voltage engine will not start; if VDC PWR voltage falls velow 22 volts will set sensor faults.*

NOTE: ***[5]*** *Shift Switch - will activate code when engine rpm are above 3500 rpm and 40% load.*

Manifold Vacuum / Pressure Reference Chart

Manifold Vacuum	Absolute Pressure		Manifold Vacuum	Absolute Pressure	
psi	**psi**	**kPa**	**psi**	**psi**	**kPa**
0	14.7	101.3	**7 1/4**	7.45	51.4
1/4	14.45	99.6	**7 1/2**	7.2	49.6
1/2	14.2	97.9	**7 3/4**	6.95	47.9
3/4	13.95	96.2	**8**	6.7	46.2
1	13.7	94.4	**8 1/4**	6.45	44.5
1 1/4	13.45	92.7	**8 1/2**	6.2	42.7
1 1/2	13.2	91.0	**8 3/4**	5.95	41.0
1 3/4	12.95	89.3	**9**	5.7	39.3
2	12.7	87.5	**9 1/4**	5.45	37.6
2 1/4	12.45	85.8	**9 1/2**	5.2	35.8
2 1/2	12.2	84.1	**9 3/4**	4.95	34.1
2 3/4	11.95	82.4	**10**	4.7	32.4
3	11.7	80.6	**10 1/4**	4.45	30.7
3 1/4	11.45	78.9	**10 1/2**	4.2	29.0
3 1/2	11.2	77.2	**10 3/4**	3.95	27.2
3 3/4	10.95	75.5	**11**	3.7	25.5
4	10.7	73.8	**11 1/4**	3.45	23.8
4 1/4	10.45	72.0	**11 1/2**	3.2	22.1
4 1/2	10.2	70.3	**11 3/4**	2.95	20.3
4 3/4	9.95	68.6	**12**	2.7	18.6
5	9.7	66.9	**12 1/4**	2.45	16.9
5 1/4	9.45	65.1	**12 1/2**	2.2	15.2
5 1/2	9.2	63.4	**12 3/4**	1.95	13.4
5 3/4	8.95	61.7	**13**	1.7	11.7
6	8.7	60.0	**13 1/4**	1.45	10.0
6 1/4	8.45	58.2	**13 1/2**	1.2	8.3
6 1/2	8.2	56.5	**13 3/4**	0.95	6.5
6 3/4	7.95	54.8	**14**	0.7	4.8
7	7.7	53.1	**14 1/4**	0.45	3.1
			14 1/2	0.2	1.4

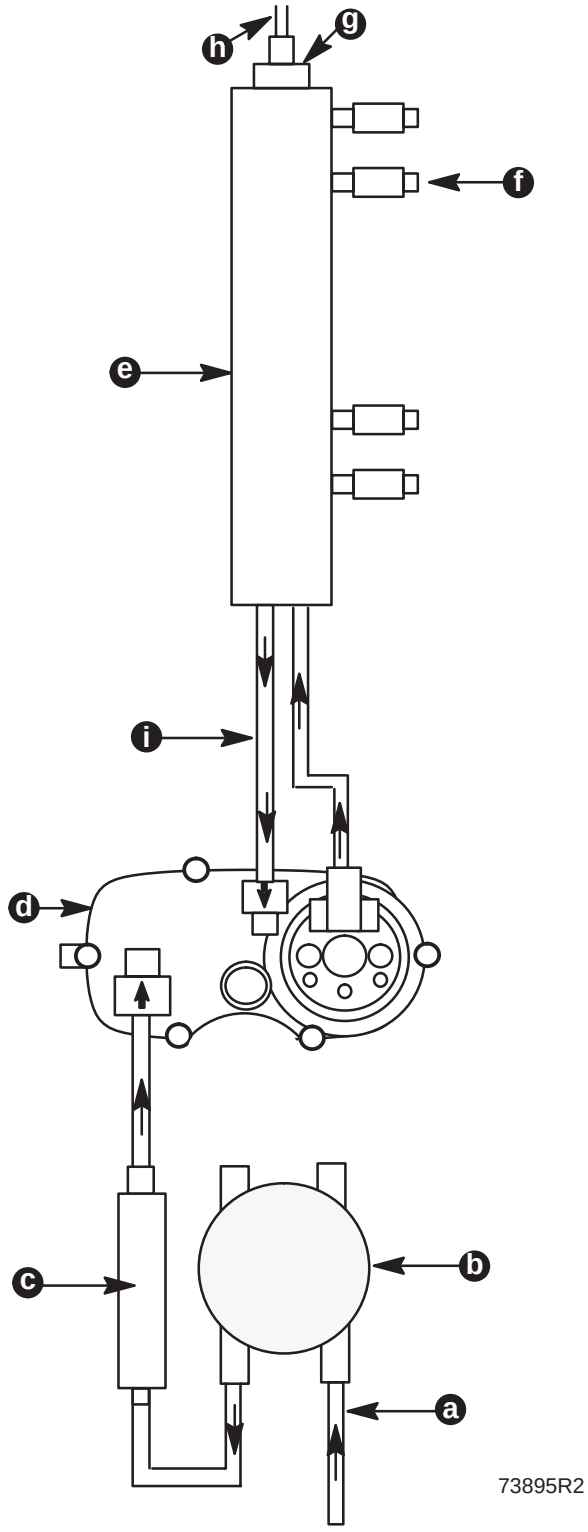
Vacuum Gauge vs MAP Sensor


MAP Sensor (Volt)
MAP Sensor (kPa absolute)
MAP Sensor (in Hg absolute)
MAP Sensor (psi)
Hand Held Vacuum Gauge (in Hg)
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30

This graph is correct at Sea Level only.

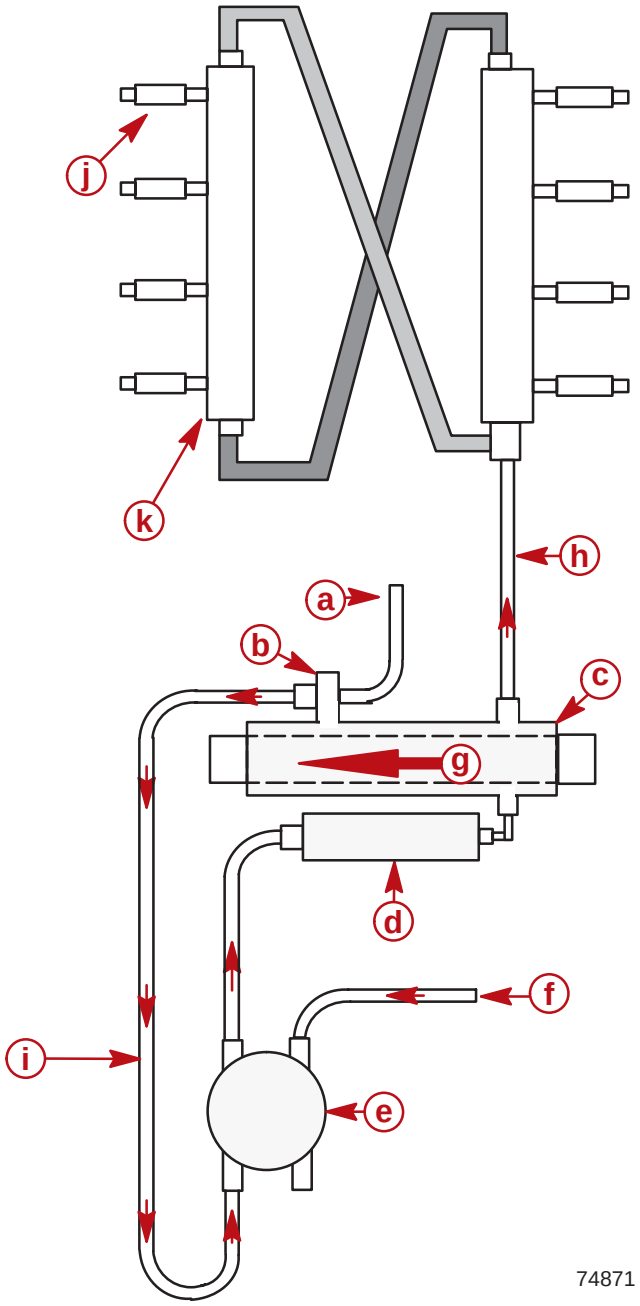
Fuel Systems Diagrams

Multi-Port Injection With Vapor Separator Tank (VST)



a - Fuel line from boat's fuel tank
b - Water separating fuel filter
c - Supply pump (mechanical or electric)
d - Vapor separator tank
e - Fuel rail
f - Fuel injectors (8)
g - Fuel pressure regulator
h - Vacuum line to intake manifold
i - Return line to vapor separator tank

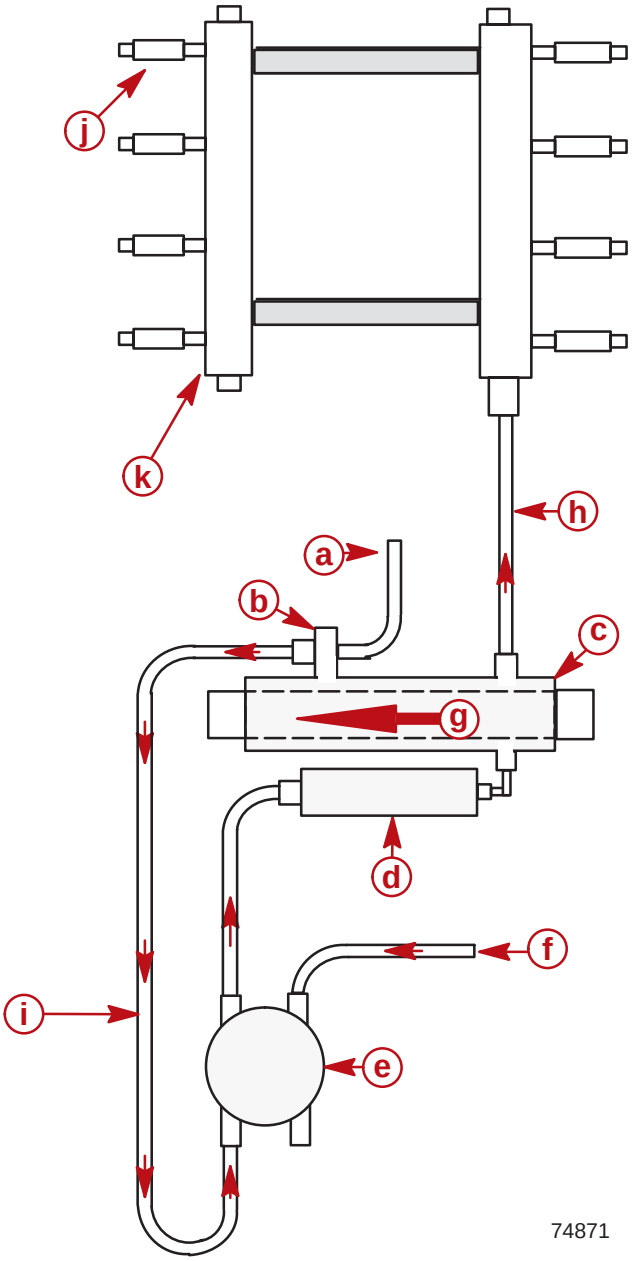
350 Magnum Multi-Port Injection with MEFI 1 and MEFI 2



350 Mag MPI Shown - Scorpion Is Similar

a - Vacuum Line To Intake Manifold Base
b - Fuel Pressure Regulator
c - Fuel Cooler
d - Electric Fuel Pump
e - Water Separating Fuel Filter
f - Fuel From Tank
g - Direction Of Water Flow
h - Fuel Line To Fuel Rail
i - Excess Fuel Return To Water Separating Fuel Filter
j - Fuel Injectors (8)
k - Fuel Rail

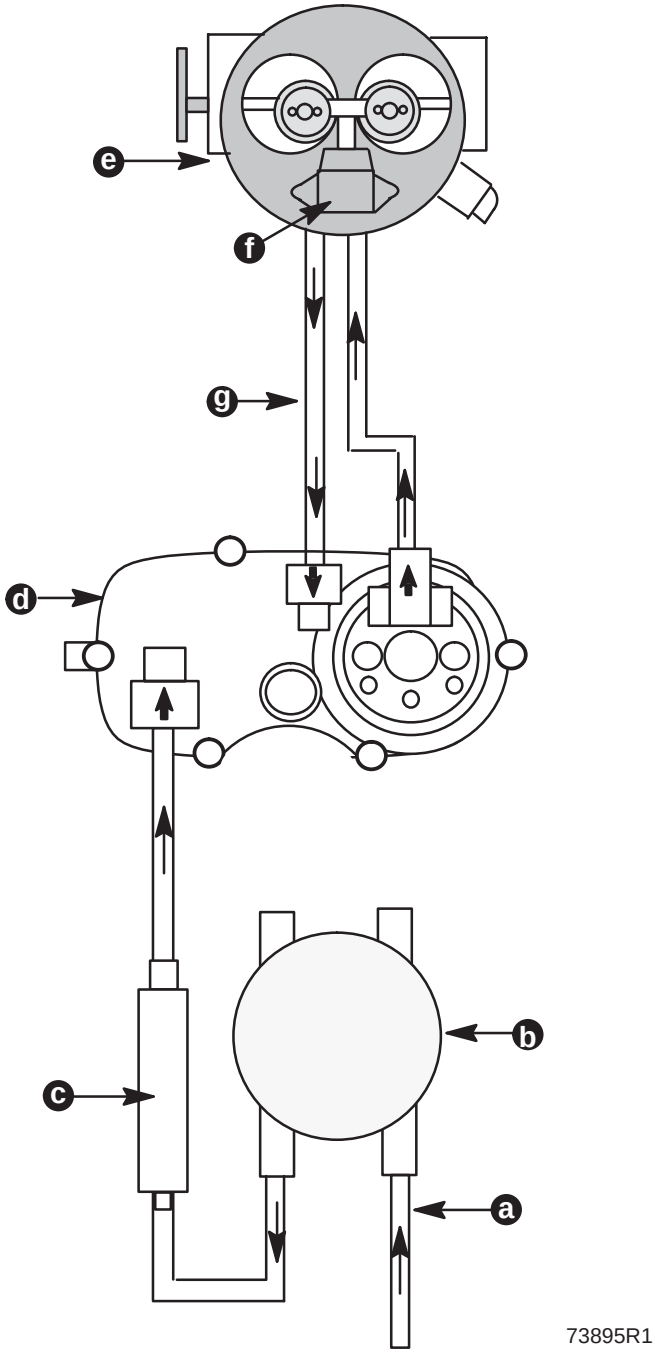
350 Magnum Multi-Port Injection with MEFI 3



350 Mag MPI Shown - Scorpion Is Similar

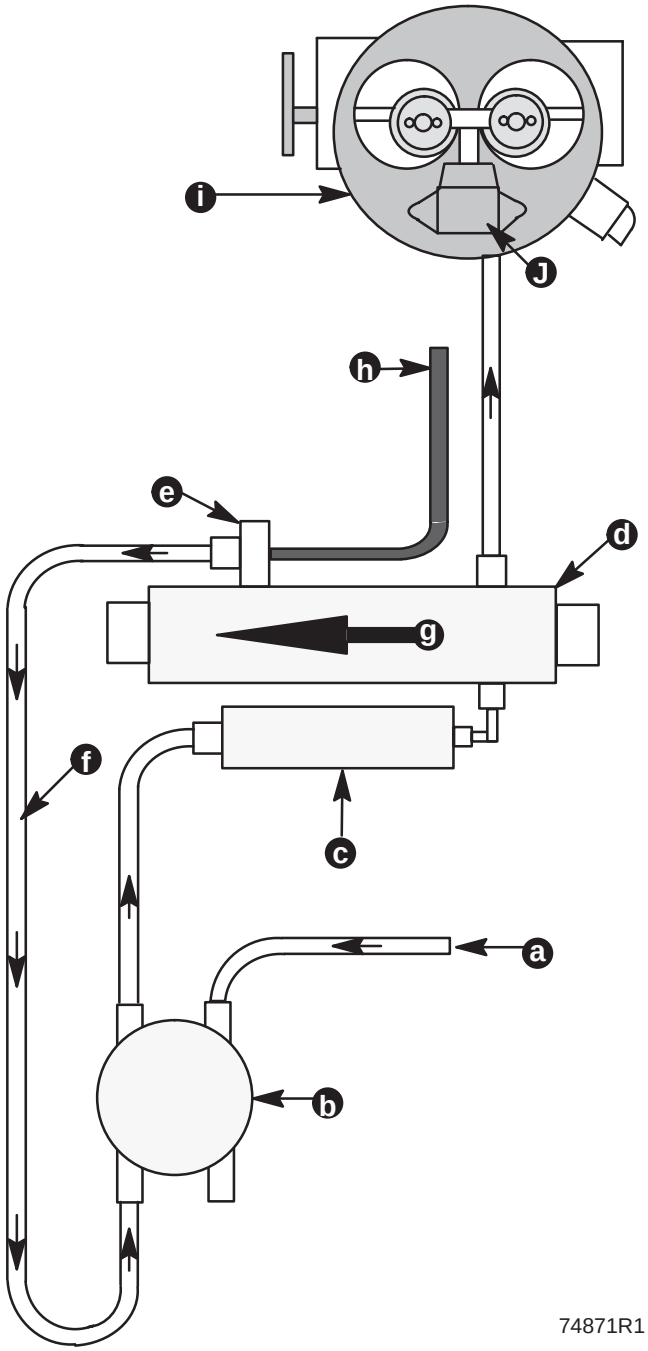
a - Vacuum Line To Intake Manifold Base
b - Fuel Pressure Regulator
c - Fuel Cooler
d - Electric Fuel Pump
e - Water Separating Fuel Filter
f - Fuel From Tank
g - Direction Of Water Flow
h - Fuel Line To Fuel Rail
i - Excess Fuel Return To Water Separating Fuel Filter
j - Fuel Injectors (8)
k - Fuel Rail

Throttle Body Injection With Vapor Separator Tank (VST)



a - Fuel line from boat's fuel tank
b - Water separating fuel filter
c - Supply pump (mechanical or electric)
d - Vapor separator tank
e - Throttle body with 2 fuel injectors
f - Fuel pressure regulator
g - Return line to vapor separator tank

Throttle Body Injection With Cool Fuel System

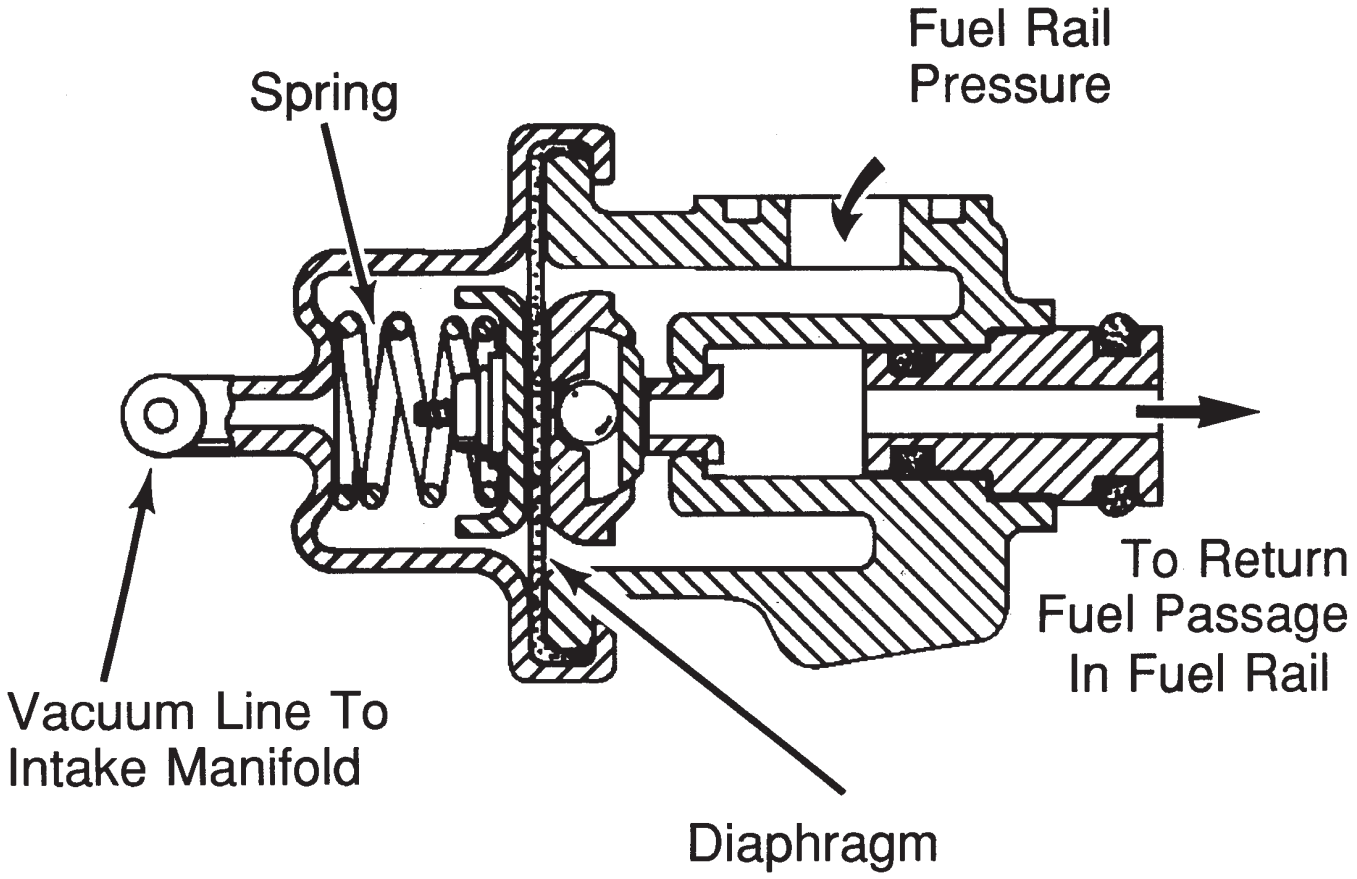


a - Fuel line from boat's fuel tank
b - Water separating fuel filter
c - Electric fuel pump
d - Fuel cooler
e - Fuel pressure regulator
f - Return line to fuel filter
g - Water flow through cooler
h - Vent line to flame arrestor
i - Throttle body with 2 fuel injectors
j - "dummy" fuel pressure regulator

Fuel Pressure Regulator Assembly

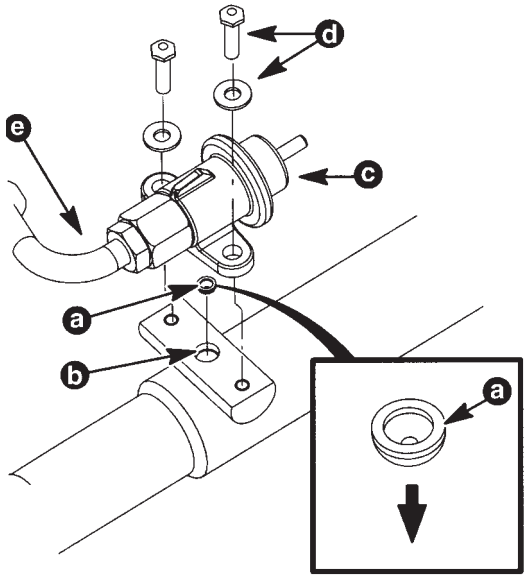
The pressure regulator is a diaphragm-operated relief valve with fuel pump pressure on one side, and regulator spring pressure and intake manifold vacuum on the other. The regulator's function is to maintain a constant pressure differential across the injectors at all times. The pressure regulator compensates for engine load by increasing fuel pressure as engine vacuum drops.

If the pressure is too hi or low, poor performance can result.



“Cool Fuel” System Fuel Pressure Regulators

There are 3 different “Cool Fuel”, fuel pressure regulators that are used in production. If the wrong regulator is used on an engine, that engine can have a problem with its fuel supply to the injectors. When checking regulator pressure on MPI engines, always remove the small black hose that goes to the regulator before the test. This hose goes to the intake manifold or plenum and it has vacuum on it, which causes the pressure to read lower at idle RPM. By removing the hose, the regulator’s true pressure will be shown.



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a - Filter
b - Fuel Cooler Orifice
c - Pressure Regulator
d - Screw and Washer
e - Fuel Line

There are 2 ways of identifying each regulator by looking at them. By a colored paint mark on its’ mounting flange and by a small ring that is on the regulator’s hose fitting.

ALL TBI ENGINES AND SMALL BLOCK MPI ENGINES:
(Black Scorpion, with Cool Fuel module on starboard side, has a 43 PSI fuel system)

30 psi (207 kPa)

Paint Mark: Pink

Ring on Regulator’s Hose Fitting: None.

ALL 7.4L MPI (L29) ENGINES AND ALL 454/502 MAG EFI/MPI ENGINES WITH MEFI-3 ECM’S AND ECM/PCM 555 ENGINES:

43 psi (296 kPa)

Paint Mark: Blue

Ring on Regulator’s Hose Fitting: Green.

ALL 454/502 MAG MPI ENGINES WITH MEFI-1 ECM’S:

36 psi (248 kPa)

Paint Mark: Yellow and Orange

Ring on Regulator’s Hose Fitting: Black.

Fuel Pressure Regulator Identification (Revised Aug. 6, 2004)

- **ECM and PCM 555 Fuel Regulator Identification**

Engine Model	Color Code	System psi (kPa)	Regulator P/N	Comments
V6 4.3L, V8 5.7L, 6.2L, ECM 555, (MPI, Cool Fuel, GM MPI intake, GMEFI system).				
V6 4.3L, V8 5.0L, 350 Mag, MX6.2 Models	Blue/Brown	43 (296)	861126A 1	Regulator on fuel cooler. Green ring on hose fitting.
V8 5.7L, 6.2L, ECM 555, (MPI, Cool Fuel, MerCruiser 320 EFI style intake, plenum, Keihin injectors).				
Black Scorpion (5.7L & 6.2L), 377 Scorpion Bravo & Ski	Pink	30 (207)	807952A 1	Regulator on fuel cooler. No ring on hose fitting.
V8 5.0L, 5.7L, 6.2L, ECM 555, (MPI, **Gen 3 Cool Fuel**, GM MPI intake, GMEFI system).				
5.0L MPI, 350 Mag, MX6.2 Models	None	**42.5 (288)**	**892681**	**Regulator in top of Gen 3 Cool Fuel Module**
V8 8.1L, PCM 555, (MPI, Cool Fuel, GM intake, plenum, injectors).				
V8 496 Mag, 8.1S Models	Blue/Brown	43 (296)	861126A 1	Regulator on fuel cooler. Green ring on hose fitting.
V8 8.1L, PCM 555, (MPI, **Gen 3 Cool Fuel**, GM intake, plenum, injectors).				
V8 496 Mag, 8.1S Models	None	**42.5 (288)**	**892681**	**Regulator in top of Gen 3 Cool Fuel Module**

- **MEFI-1, -2, -3 ECM Fuel Regulator Identification**

Engine Model	Color Code	System psi (kPa)	Regulator P/N	Comments
V8 5.7L, MEFI-1, (TBI, VST, Non-Gen+ engines, GM TBU).				
350 Mag EFI Ski	Unknown	12 (82)	None	Regulator in TBU. See SB 94-8.
V6 4.3L, V8 5.0L, 5.7L, MEFI-1, (TBI, VST, Non Gen+ and Gen+ engines, GM TBU).				
All V6 EFI, all V8 EFI models	Unknown	30 (207)	852955	Regulator in TBU
V6 4.3L, V8 5.0L, 5.7L, MEFI-1, -3, (TBI, Cool Fuel engines, GM TBU).				
All V6 EFI, all V8 EFI models	Unknown	30 (207)	852955	Regulator in TBU
V8 5.7L, MEFI-1, (MPI, VST, Non-Gen+ engines, Keihin injectors).				
350 Mag MPI Bravo, Ski	Unknown	43 (296)	806808A 2	Regulator on the fuel rail.
V8 5.7L, MEFI-1, (MPI, VST, Gen+ engines, Keihin injectors).				
350 Mag MPI Bravo	Unknown	43 (296)	806808A 2	Regulator on fuel rail.
V8 5.7L, MEFI-1, (MPI, Cool Fuel on Starboard side, Gen+ engines, Keihin injectors).				
Black Scorpion Ski (5.7L)	Unknown	43 (296)	808062A 1	Regulator on fuel rail.

- **MEFI-1, -2, -3 ECM Fuel Regulator Identification - Contd.**

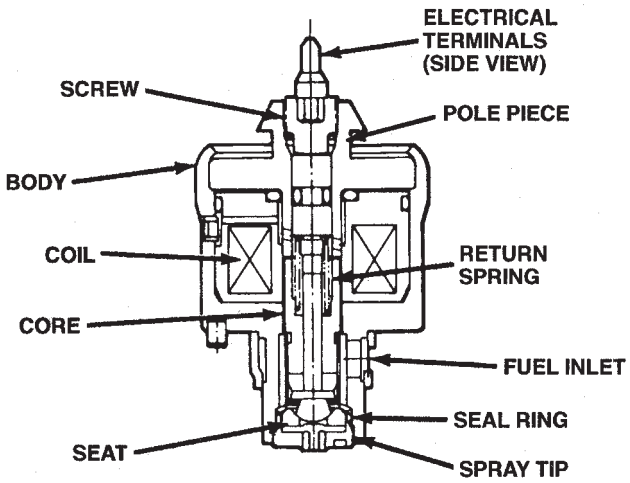
Engine Model	Color Code	System psi (kPa)	Regulator P/N	Comments
V8 5.7L, MEFI-1, (MPI, Cool Fuel on Port side, Gen+ engines, Keihin injectors).				
350 Mag MPI Bravo, Inbrd, Ski, Black Scorpion Ski	Pink	30 (207)	807952A 1	Regulator on fuel cooler. No ring on hose fitting.
V8 5.7L, 6.2L, MEFI-2, -3, (MPI, Cool Fuel on Port side, Gen+ engines, Magneti-Marelli injectors).				
350 Mag MPI Alpha, Bravo, Inbrd, Ski, and MX 6.2 MPI Bravo, Inbrd	Pink	30 (207)	807952A 1	Regulator on fuel cooler. No ring on hose fitting.
V8 5.7L, 6.2L, MEFI-3, (MPI, Cool Fuel on Port side, Gen+ engines, Keihin injectors).				
Black Scorpion (5.7L & 6.2L)	Pink	30 (207)	807952A 1	Regulator on fuel cooler. No ring on hose fitting.
V8 7.4L (L29), MEFI-2, -3, (MPI, Cool Fuel, GM MPI intake, plenum, injectors).				
7.4L MPI Bravo & Inbrd	Blue/Brown	43 (296)	861126A 1	Regulator on fuel cooler. Green ring on hose fitting. GM regulator on the fuel rail does not operate or control fuel psi.
V8 7.4L MEFI-1, (GM TBI, Cool Fuel, GM TBI intake, GM TBU).				
7.4LX EFI Bravo, 7.4L EFI Inbrd	Pink	30 (207)	807952A 1	Regulator on fuel cooler. No ring on hose fitting.
V8 7.4L, 8.2L, MEFI-1, (MPI, VST, MerCruiser MPI intake, Keihin injectors).				
All 7.4L & 8.2L MPI models	Unknown	36 (248)	805227A 1	Regulator on fuel rail. Hose fitting points toward port side.
V8 7.4L, 8.2L, MEFI-1, (MPI, Cool Fuel, MerCruiser MPI intake, Keihin injectors).				
All 7.4L & 8.2L MPI models	Yellow/ Orange	36 (248)	860349A 1	Regulator on fuel cooler. Black ring on hose fitting. Regulator on fuel rail does not control fuel pressure.
V8 7.4L, 8.2L, MEFI-3, (MPI, Cool Fuel, MerCruiser MPI intake, Magneti-Marelli injectors).				
All 7.4L & 8.2L All 7.4L & 8.2L	Blue/	43 (296)	861126A 1	Regulator on fuel cooler. Green ring on hose fitting. No regulator on the fuel rail.
V8 8.2L, MEFI-3, (MPI, Cool Fuel, MerCruiser MPI intake).				
HP500 EFI	Blue/ Brown	43 (296)	861126A 1	[1999-UP]. Green ring on hose fitting.
V8 8.2L, MEFI-3, (Dual TBI, Cool Fuel, Super Charger intake, GM TBU).				
HP575 SCi	Pink	30 (207)	807952A 1	[2000-UP].No ring on hose fitting.

Fuel Injectors

The EFI injector assembly is a solenoid-operated device, controlled by the ECM, that meters pressurized fuel to engine cylinders. The ECM grounds the injector solenoid, which opens a valve, allowing fuel to flow past the valve. The injector tip has holes that control the fuel flow, generating a conical spray pattern of finely atomized fuel at the injector tip. On throttle body systems, fuel is directed into the bore of the Throttle Body Assembly, and then it passes into the intake manifold.

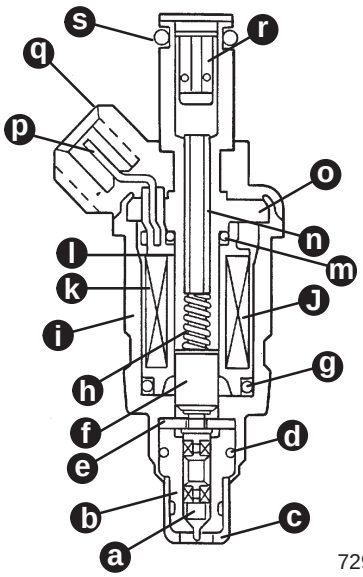
On MPI models, fuel is directed at the intake valve, causing it to become further atomized and vaporized before entering the combustion chamber.

Throttle Body Injection (TBI) Fuel Injector



Multi-Port Injection (MPI) Fuel Injector

a - Needle Valve
b - Nozzle
c - Cap
d - O-Ring
e - Valve Stopper
f - Core
g - O-Ring
h - Spring
i - Housing
j - Solenoid Coil
k - Tape
l - Bobbin
m - O-Ring
n - Inner Collar
o - Sleeve
p - Terminal
q - Connector
r - Filter
s - O-Ring



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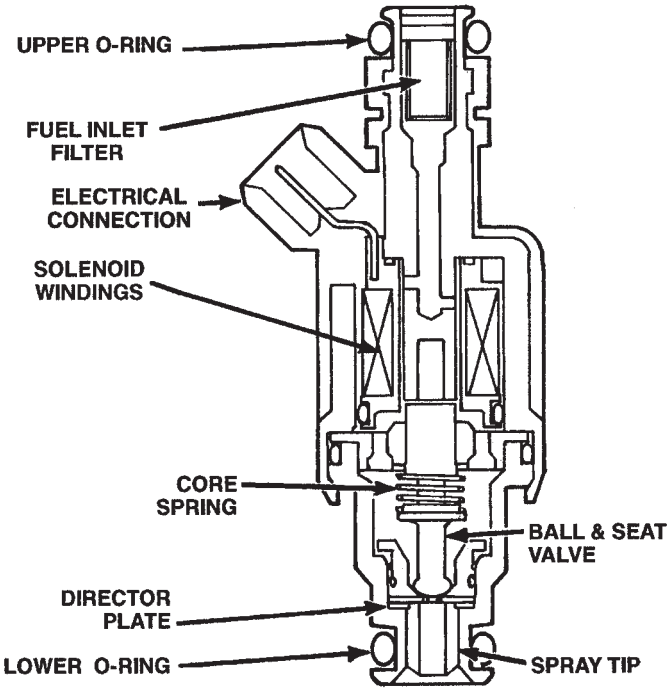
Early 454/502 Models



7.4L (454 c.i.) L-29 Models

Fuel Injector Identification (Revised Aug. 6, 2004)

- **ECM and PCM 555 Engine Injector Identification**

Engine Model	Color Code	System psi (kPa)	Injector P/N	[Manufacture] Comments
V6 4.3L, V8 5.7L, 6.2L, ECM 555, (MPI, Cool Fuel, GM MPI intake, GMEFI system).				
V6 4.3L, V8 5.0L, 350 Mag, MX6.2 Models	Neutral Tip	43 (296)	885176	[GM].
V8 5.7L, 6.2L, ECM 555, (MPI, Cool Fuel, MerCruiser 320 EFI style intake, plenum, Keihin injectors).				
Black Scorpion (5.7L & 6.2L)	White Tip	30 (207)	805225A 1	[Keihin].
V8 8.1L, PCM 555, (MPI, Cool Fuel, GM intake, plenum, injectors).				
V8 496 Mag, 8.1S Models	Black Tip	43 (296)	881693	[GM]. Delphi.
	Neutral Tip	43 (296)	881693	[GM]. Delphi.

- **MEFI-1, -2, -3 ECM Engine Injector Identification**

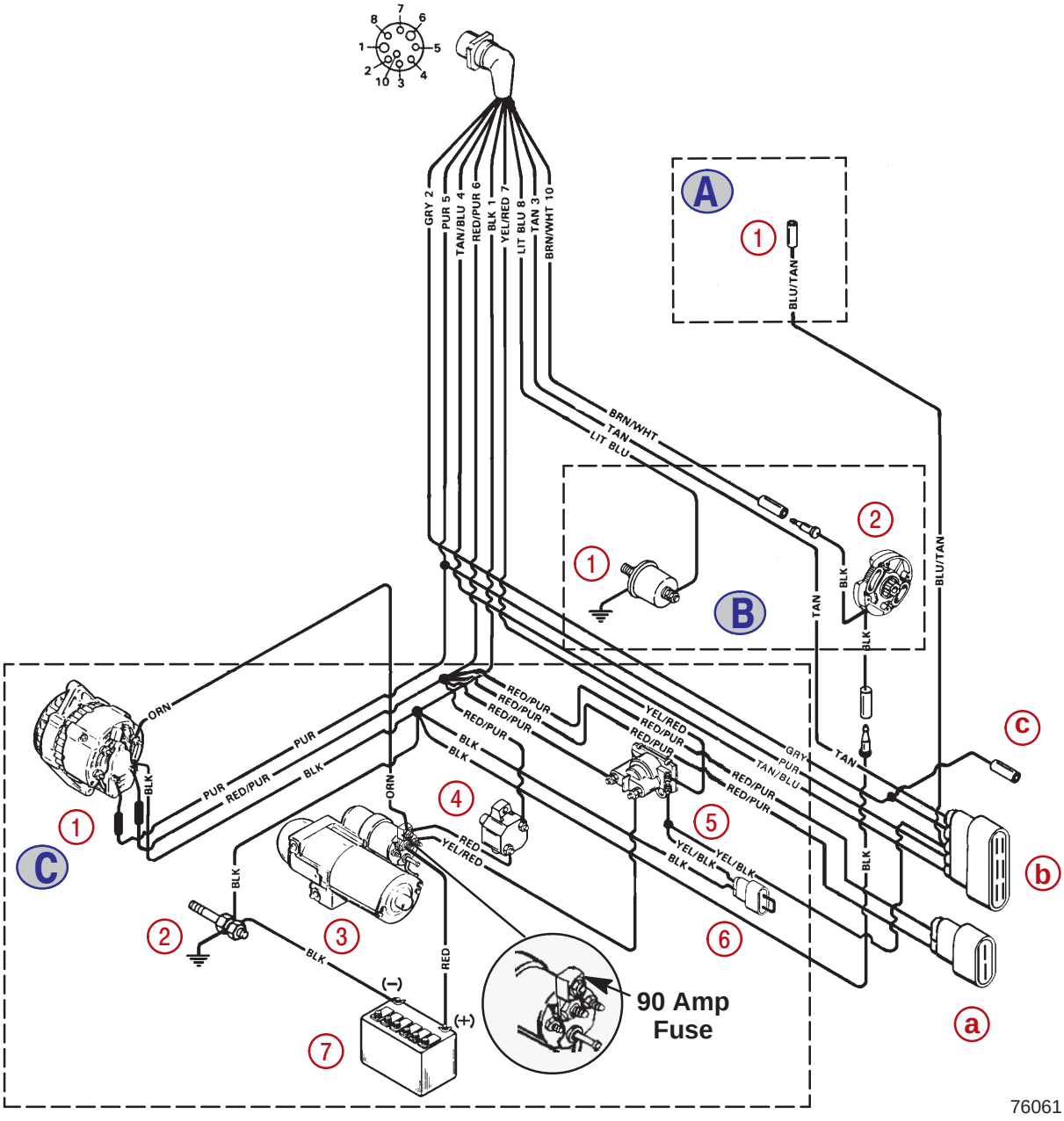
Engine Model	Color Code	System psi (kPa)	Injector P/N	[Manufacture] Comments
V8 5.7L, MEFI-1, (TBI, VST, Non-Gen+).				
350 Mag EFI Ski	Blue/Black	12 (82)	None	[GM]. See SB 94-8.
V6 4.3L, V8 5.0L, 5.7L, MEFI-1, (TBI, VST and Cool Fuel, Non-Gen+ and Gen+ engines).				
All V6 EFI, all V8 EFI models	Pink/Purple	30 (207)	852956	[GM].
V8 5.7L, MEFI-1, (MPI, VST, Non-Gen+).				
350 Mag MPI Bravo, Ski	Orange Tip	43 (296)	806807A 1	[Keihin].
V8 5.7L, MEFI-1, (MPI, VST, Gen+).				
350 Mag MPI Bravo	Orange Tip	43 (296)	806807A 1	[Keihin].
V8 5.7L, MEFI-1, (MPI, Cool Fuel on Starboard side, Gen+).				
Black Scorpion Ski (5.7L)	Orange Tip	43 (296)	806807A 1	[Keihin].
V8 5.7L, 6.2L, MEFI-1, -3, (MPI, Cool Fuel on Port side, Gen+).				
350 Mag MPI Bravo, Inbrd, Ski, Black Scorpion Ski (5.7L & 6.2L), 377 Scorpion Bravo & Ski	White Tip	30 (207)	805225A 1	[Keihin].

- **MEFI-1, -2, -3 ECM Engine Injector Identification - Contd.**

Engine Model	Color Code	System psi (kPa)	Injector P/N	[Manufacture] Comments
V8 5.7L, 6.2L, MEFI-2, -3, (MPI, Cool Fuel on Port side, Gen+).				
350 Mag MPI Alpha, Bravo, Inbrd, Ski, and MX 6.2 MPI Bravo, Inbrd	None	30 (207)	861260T	[Magneti-Marelli].
V8 7.4L (L29), MEFI-2, -3, (MPI, Cool Fuel, GM MPI intake, plenum, injectors).				
7.4L MPI Bravo & Inbrd	Olive Green Band on Tip	43 (296)	802632	[GM].
V8 7.4L MEFI-1, (GM TBI, Cool Fuel, GM TBI intake).				
7.4LX EFI Bravo, 7.4L EFI Inbrd	Yellow/Black	30 (207)	853998	[GM].
V8 7.4L, 8.2L, MEFI-1, (MPI, VST and Cool Fuel, MerCruiser MPI intake).				
All 7.4L & 8.2L MPI models	White Tip	36 (248)	805225A 1	[Keihin].
V8 7.4L, 8.2L, MEFI-3, (MPI, Cool Fuel, MerCruiser MPI intake).				
All 7.4L & 8.2L	None	43 (296)	861260T	[Magneti-Marelli].
All 7.4L & 8.2L				
V8 8.2L, MEFI-3, (MPI, Cool Fuel, MerCruiser MPI intake).				
HP500 EFI	(Unknown)	43 (296)	849896	[1999-UP, GM].
V8 8.2L, MEFI-3, (Dual TBI, Cool Fuel, Super Charger intake, GM TBU).				
HP575 SCi	Yellow/Black	30 (207)	853998T	[2000-UP GM].

Engine Wiring Diagrams

MEFI 3 MCM 5.0L EFI, 5.7L EFI and 350 Mag MPI Engines



A - Audio Warning Components

1. - Oil Pressure Switch

B - Instrumentation Components

1. - Oil Pressure Sender
2. - Trim Sender

a - Positive Power Wire To EFI System Harness
b - Harness Connector To EFI System Harness
c - Auxiliary Tachometer Lead

C - Charging and Starting Components

1. - Alternator
2. - Ground Stud
3. - Starter
4. - Circuit Breaker
5. - Starter Slave Solenoid
6. - Jumper Wire Connection
7. - Battery

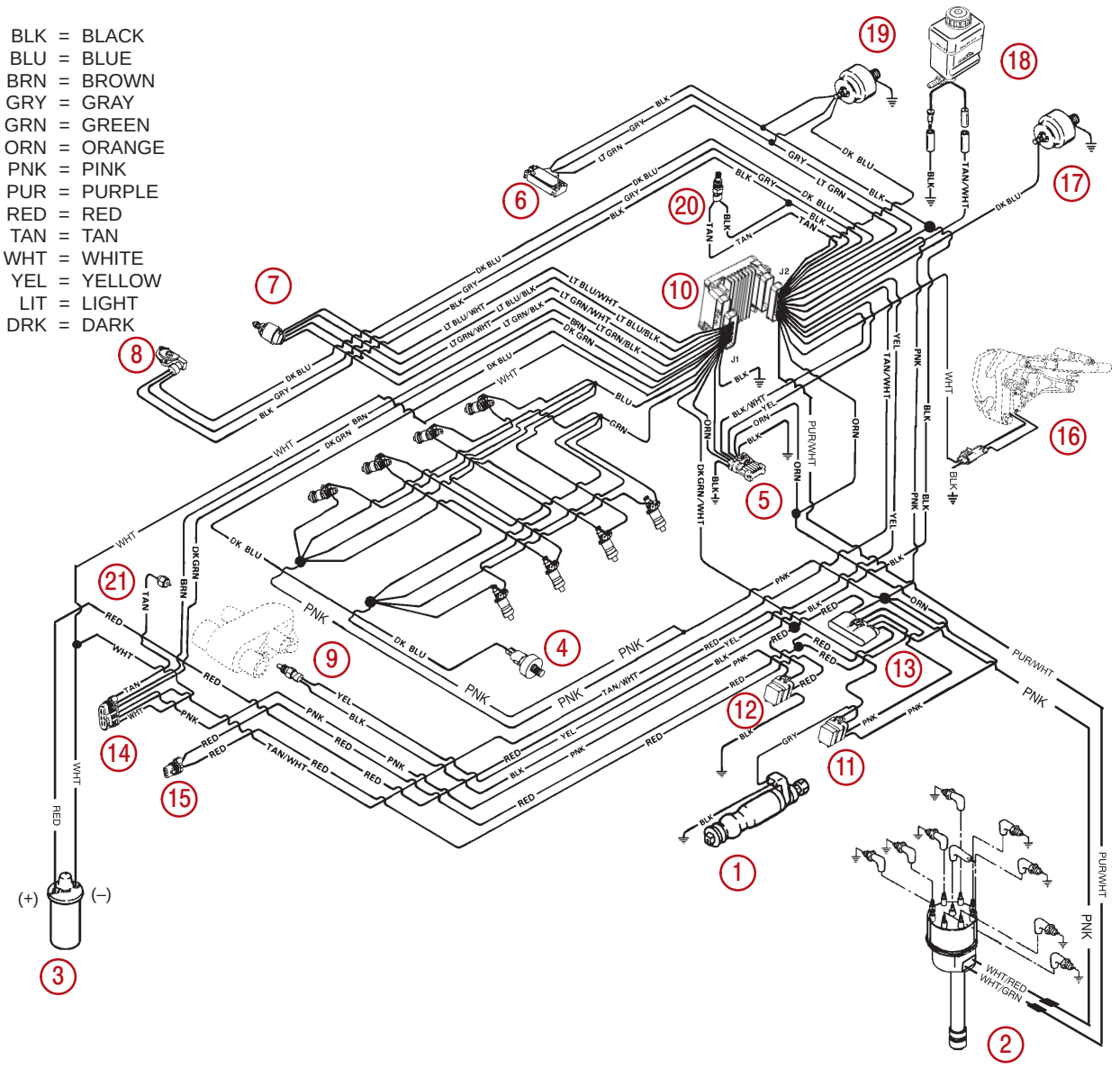
MEFI 3, 350 Magnum MPI and All Black Scorpion Engines

NOTE: *All BLACK wires with a ground symbol are interconnected within the EFI system harness.*

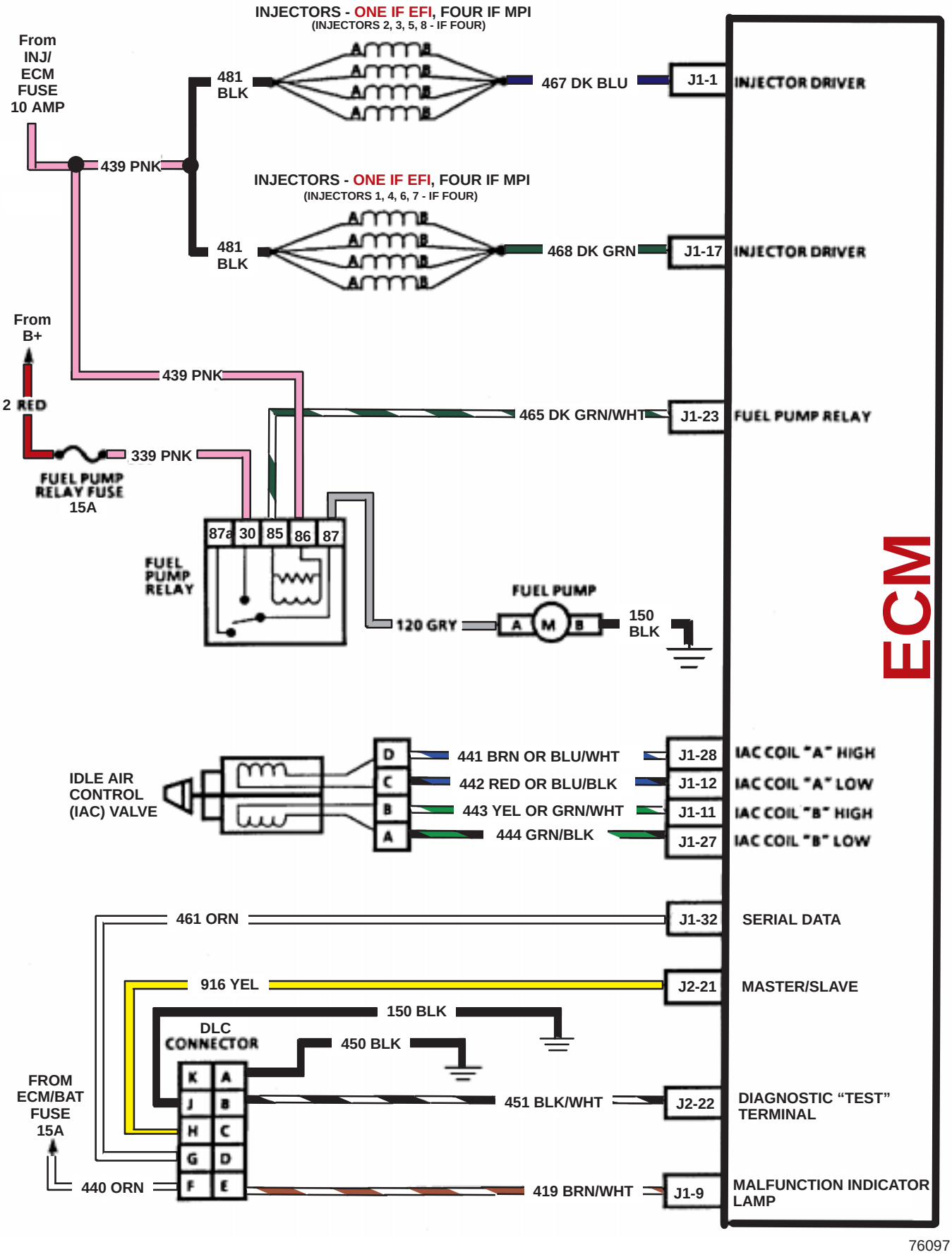
NOTE: *Component position and orientation shown is arranged for visual clarity and ease of circuit identification.*

1. - Fuel Pump
2. - Distributor
3. - Coil
4. - Knock Sensor (KS) Module
5. - Data Link Connector (DLC)
6. - Manifold Absolute Pressure (MAP) Sensor
7. - Idle Air Control (IAC)
8. - Throttle Position (TP) Sensor
9. - Engine Coolant Temperature (ECT) Sensor
10. - Electronic Control Module (ECM)
11. - Fuel Pump Relay
12. - Ignition/System Relay
13. - Fuse (15 Amp) Fuel Pump, Fuse (15 Amp) ECM/DLC/Battery, Fuse (10 Amp) ECM/Injector/Ignition/Knock Module
14. - Harness Connector To Starting/Charging Harness
15. - Positive (+) Power Wire To Engine Circuit Breaker
16. - Shift Plate (Not used on Ski models)
17. - Oil Pressure (Audio Warning System)
18. - Gear Lube Bottle (Not used on Ski models)
19. - Fuel Pressure Switch
20. - Water Temperature Sender

BLK = BLACK
BLU = BLUE
BRN = BROWN
GRY = GRAY
GRN = GREEN
ORN = ORANGE
PNK = PINK
PUR = PURPLE
RED = RED
TAN = TAN
WHT = WHITE
YEL = YELLOW
LIT = LIGHT
DRK = DARK



ECM Wiring Diagram – MEFI 3 (V6 and Small Block V8) (1 of 4)



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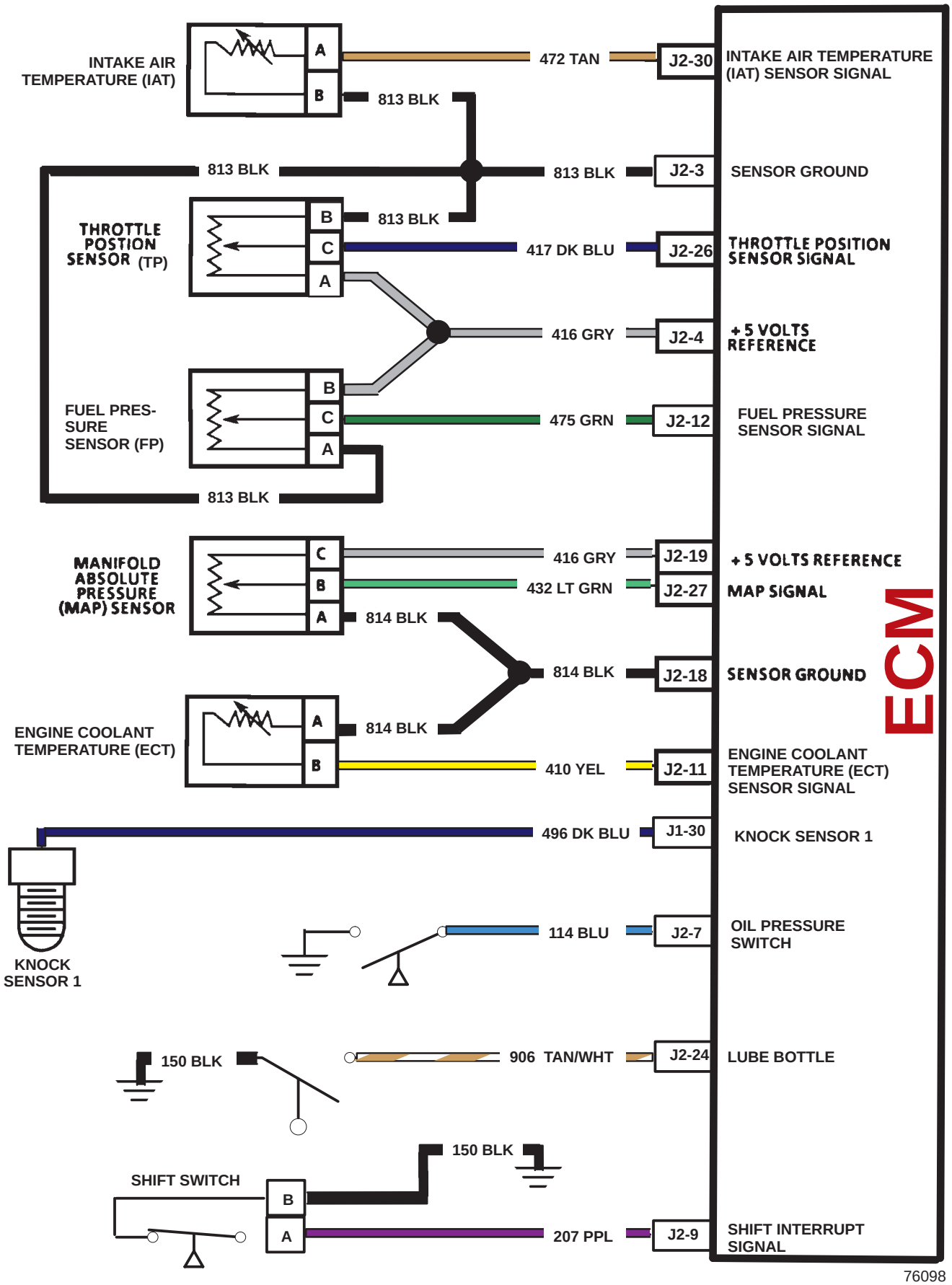
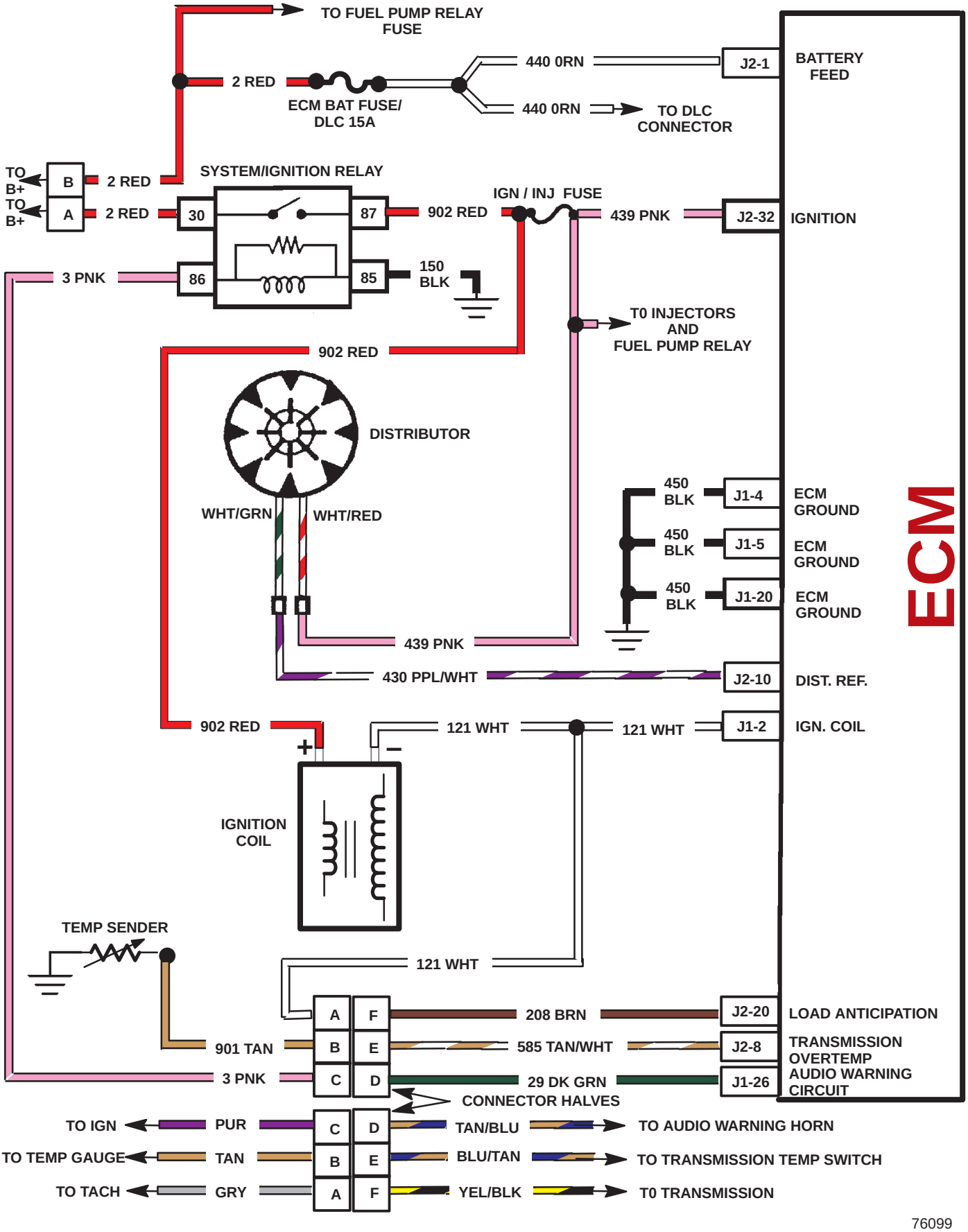
ECM Wiring Diagram – MEFI 3 (V6 and Small Block V8) (2 of 4)



ECM Wiring Diagram – MEFI 3 with Mercury Distributor (V6 and Small Block V8) (3 of 4)



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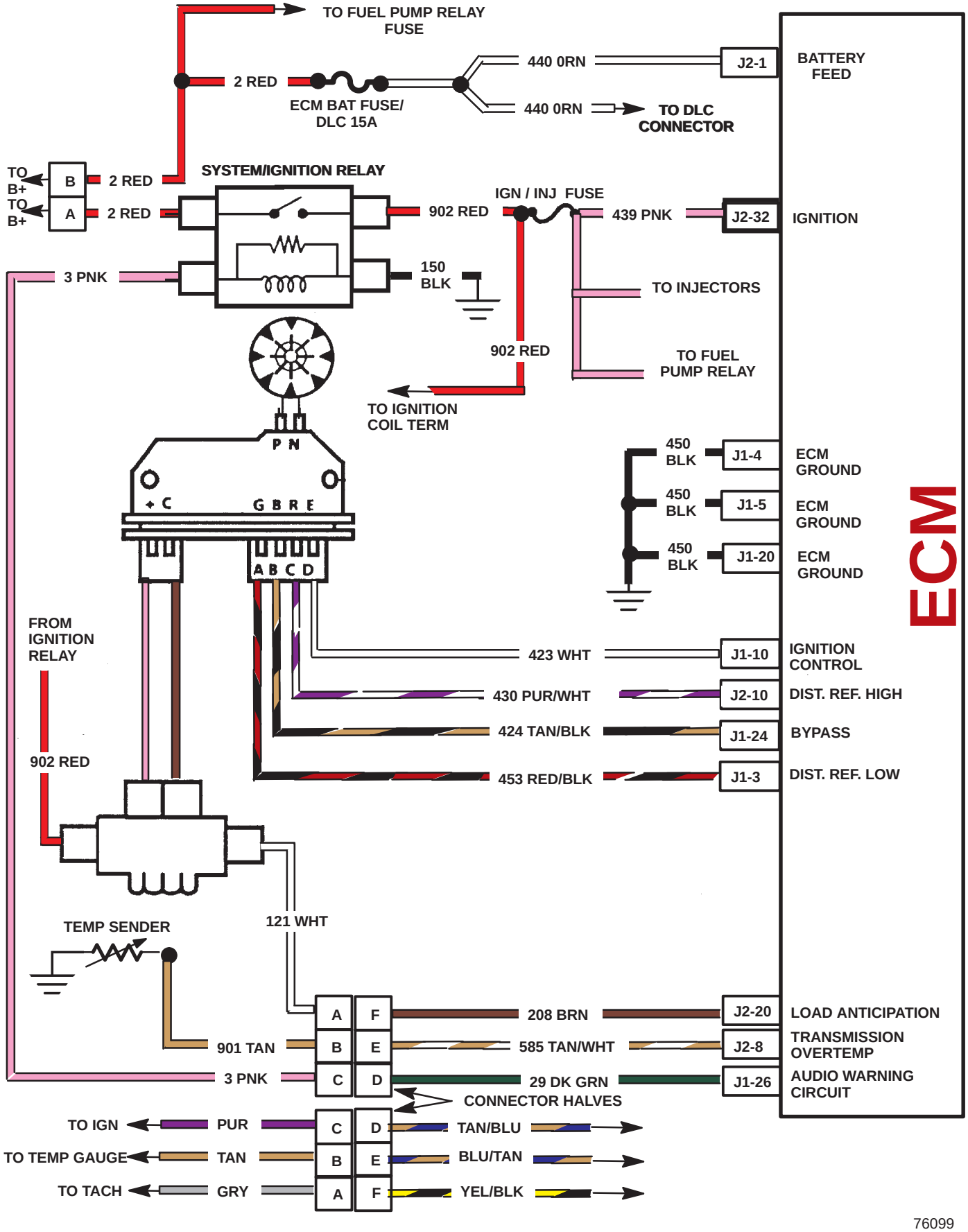
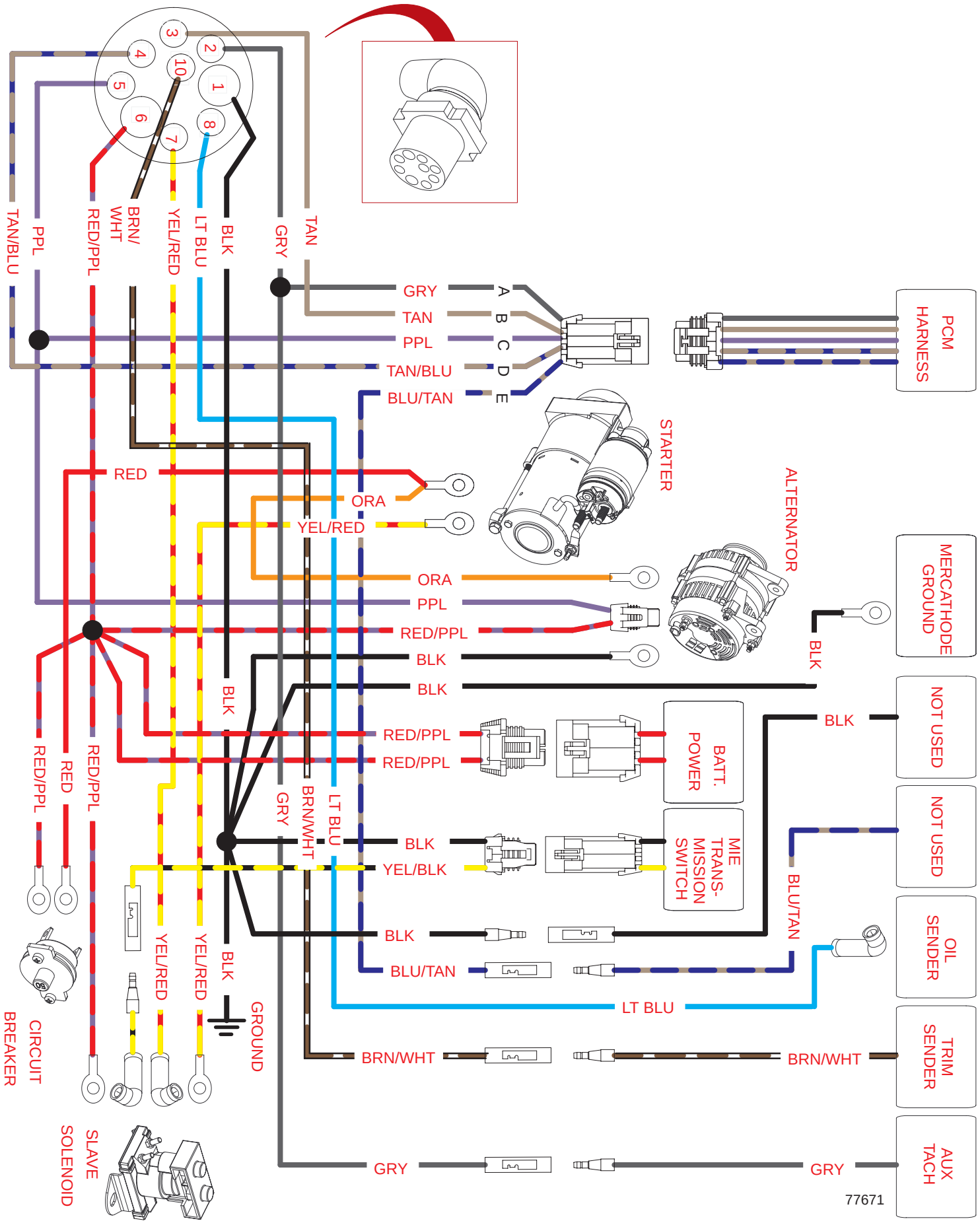
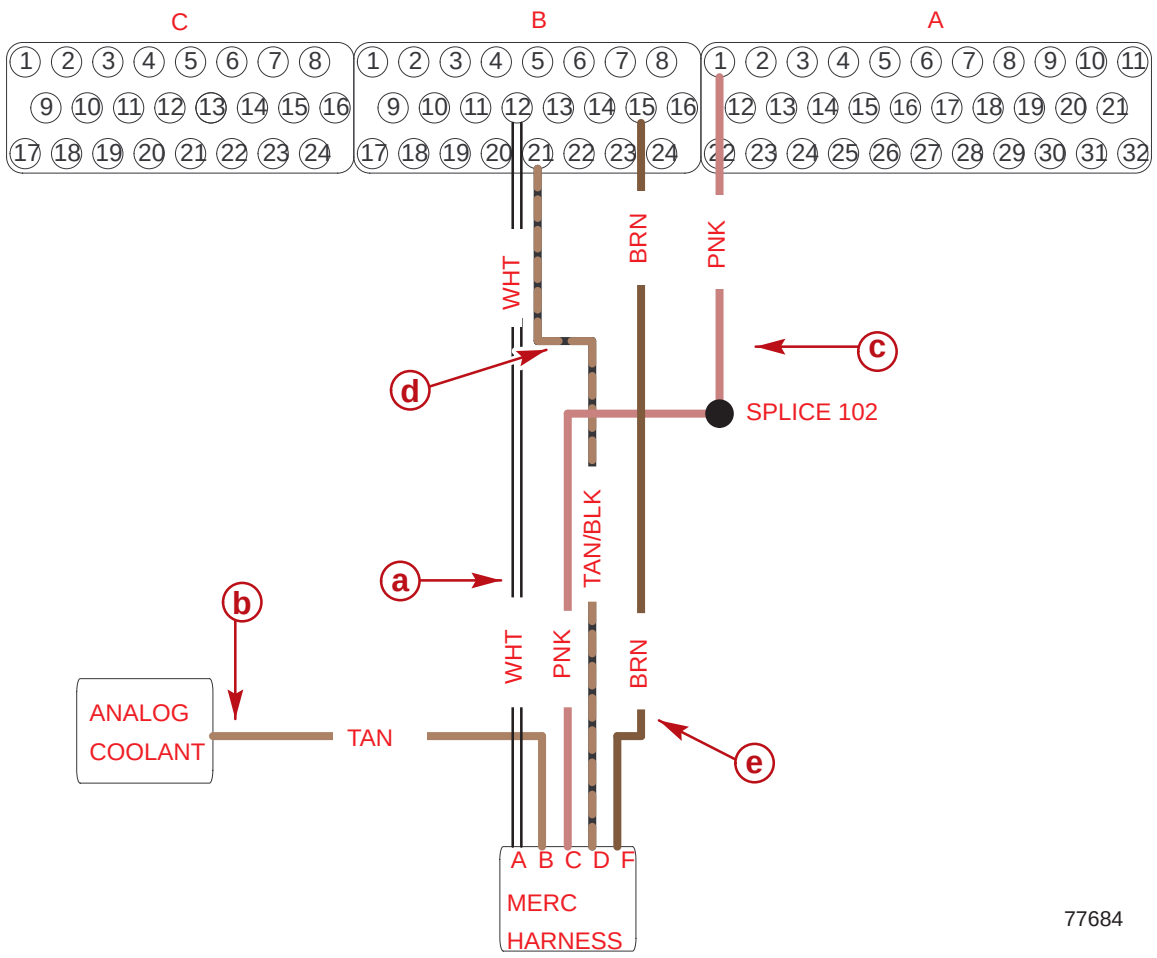
ECM Wiring Diagram – MEFI 3 with GM EST Distributor (V6 and Small Block V8) (4 of 4)



PCM 555 – Charging Harness



PCM 555 – 10 Pin Harness Circuit

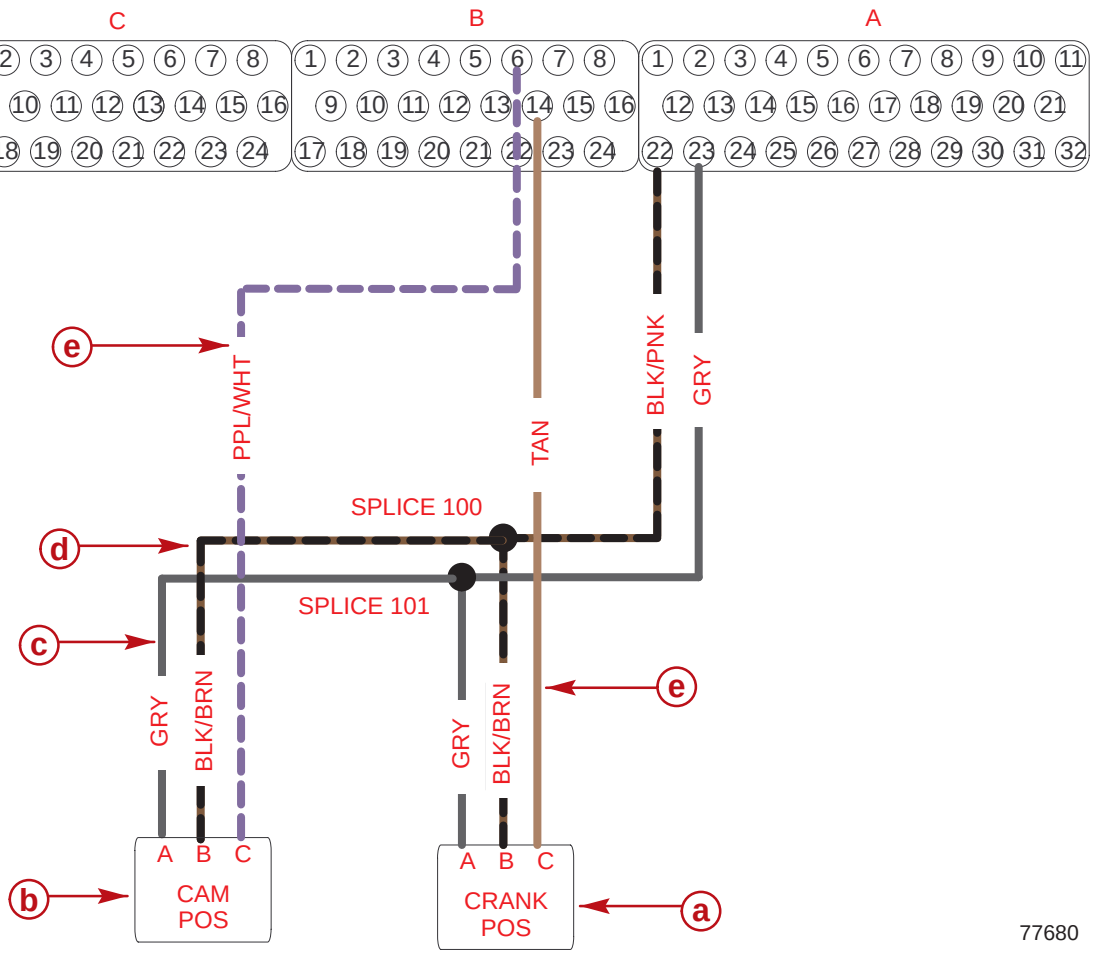


a - Tachometer Signal
b - Analog Coolant
c - 12 Volt Power
d - Audio Warning Alarm
e - Neutral Start Switch

The 10 pin harness (MERC harness) is the connecting point between the Mercury MerCruiser electronic EFI harness and the 10 pin engine harness. It supplies the PCM with the analog coolant, tachometer, audio warning alarm and neutral safety signals.

A malfunction of the 10 pin harness connection will not set a fault.

PCM 555 – Crank Position and Camshaft Position Circuits



a - Crankshaft Position Sensor
b - Camshaft Position Sensor
c - 5 Volt Power
d - 5 Volt Ground
e - Signal To The PCM

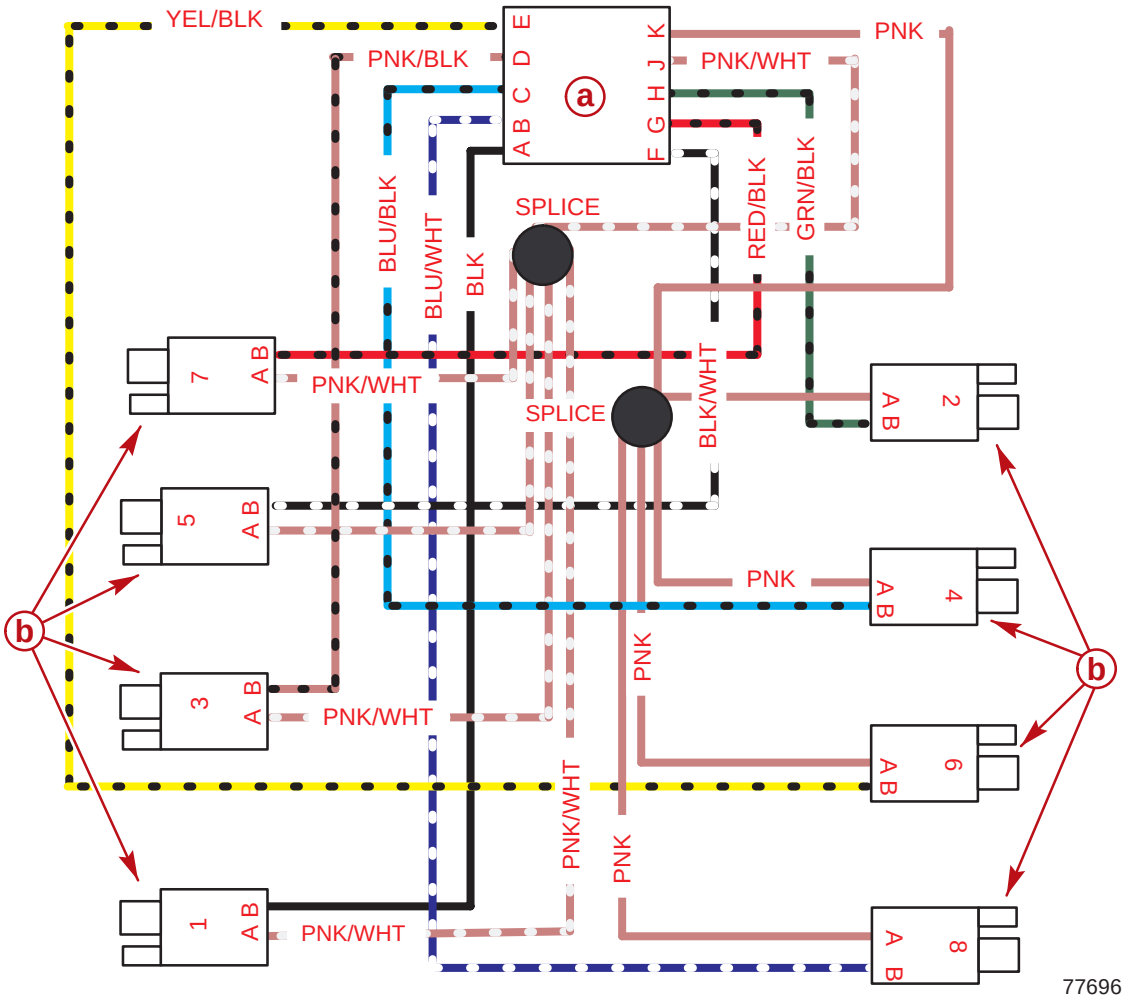
The crankshaft position sensor, located at the rear of the engine, and the camshaft position sensor, located at the front of the engine, supply the PCM with timing and rpm information. If a failure occurs in these sensor circuits, the engine will operate extremely rough or stop operating. Check for continuity between the PCM and the sensor.

The normal resistance values for these sensors at 21 degrees C (70 degrees F) are:

- Camshaft Position Sensor - A to B 24.04 mohms and B to C 24.05 mohms
- Crankshaft Position Sensor - A to B 23.2 mohms and B to C 23.21 mohms.

With software prior to level 091, a malfunction of the crankshaft position sensor or the camshaft position sensor will not set a fault. With level 091 software, if the camshaft position sensor is bad and does not send a signal to the PCM, the engine will backfire and not start. Stop cranking the engine when this occurs and then try to start the engine. Operate the engine for 20 seconds to set faults. The Audio Warning alarm will signal 2 beeps per minute. The Smartcraft system monitor will show the check engine light.

PCM 555 – Fuel Injector Harness



a - Injector Harness To Engine Harness Connector
b - Individual Injector Connectors

The fuel injectors receive fused 12 volt power from Splice 108 (Pins J and K) on the injector harness. The PCM signals the injector to fire by pulling the 12 volts to ground and completing the circuit. The normal resistance at 21 degrees C (70 degrees F) is 12.5 ohms.

A malfunction in the fuel injector harness will set the fault of FINJ 1-8 Open or FINJ 1-8 Short.

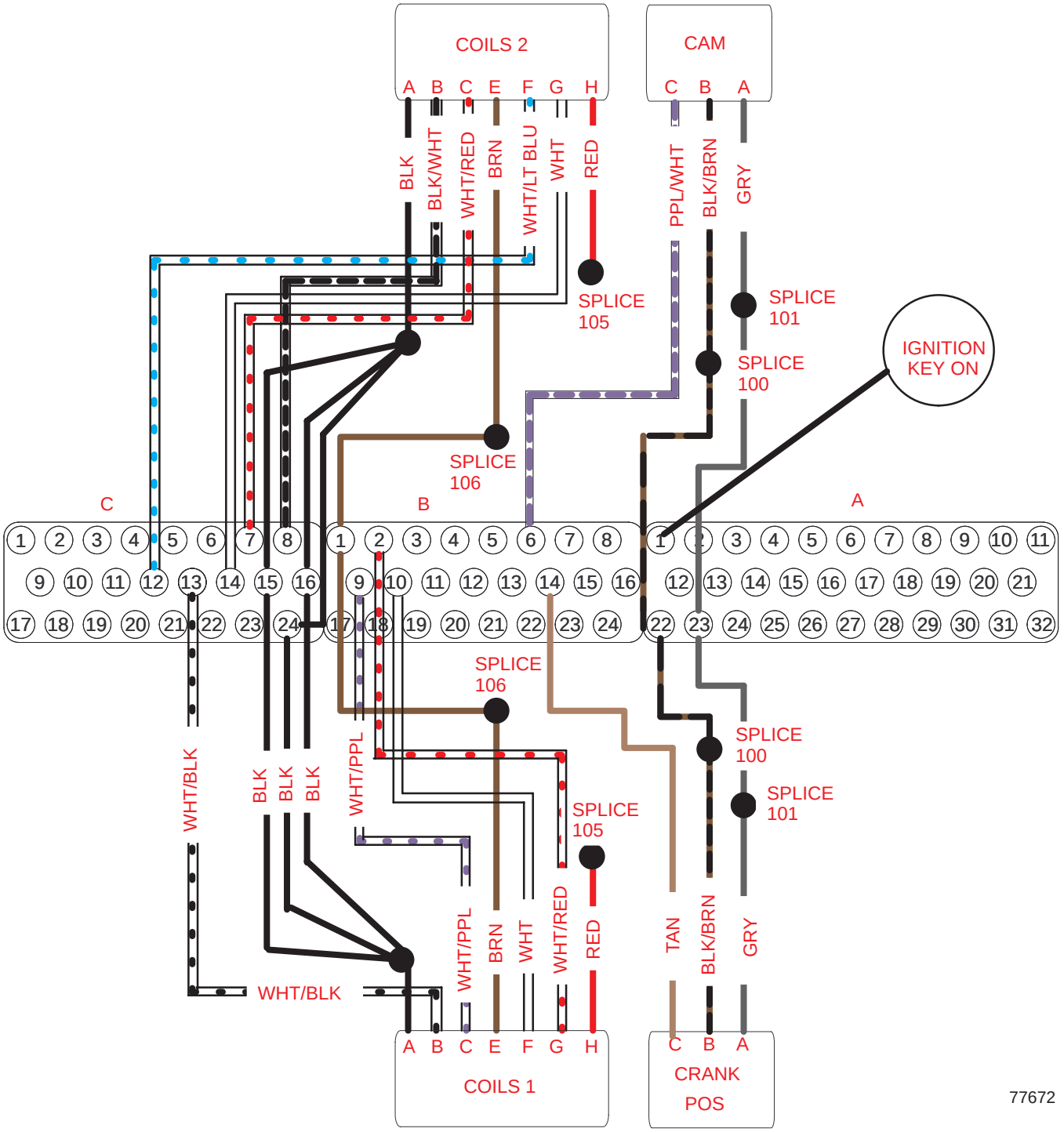
When the fuel injector driver wire is shorted to ground, the scan tool will read Open Sensor, this means that the fuel injector is full Open.

When the fuel injector is shorted, the scan tool will read Short Injector.

A shorted 12 volt fuel injector power lead will blow the injector fuse E-F; the scan tool will read Bad Fuel Pump Fuse.

Fuel Injector Number	Wire Colors on Fuel Injector Harness	PCM Pinout
1	BLK	C-6
2	GRN/BLK	C-11
3	PNK/BLK	B-22
4	BLU/BLK	B-20
5	BLK/WHT	C-23
6	YEL/BLK	C-21
7	RED/BLK	C-5
8	BLU/WHT	C-3

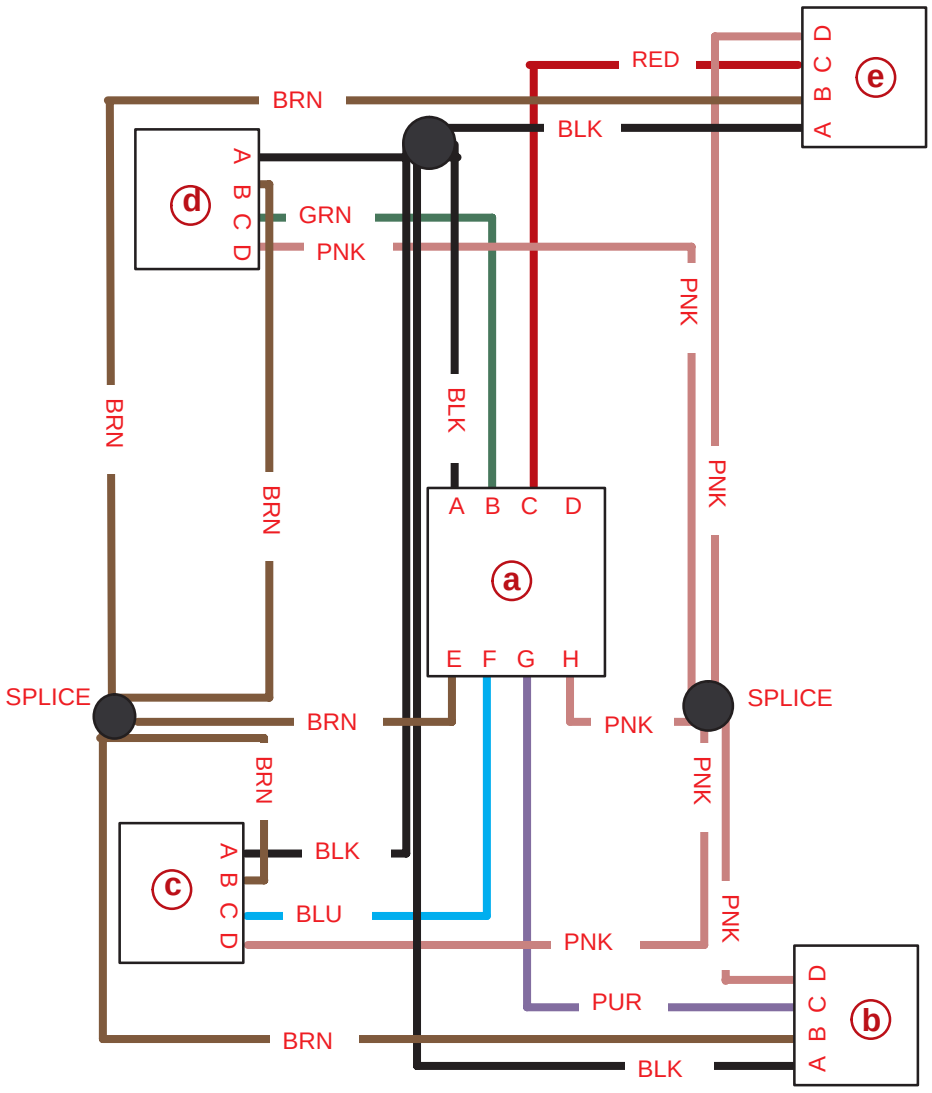
PCM 555 – Ignition Circuit



With initial key ON, 12 volt power is sent from the battery through the purple lead in the 10-pin harness to the pink lead at Engine Harness Pin C. This is wake up power to the PCM. The PCM powers pin B4 which in turn pulls the MPR low. The MPR powers the coils through Splice 105 and powers the engine for ignition.

PCM Pinout	Cyl. Number	PCM Pinout	Cyl. Number	PCM Pinout	Cyl. Number
B2	1	C8	4	B9	7
C7	2	C13	5	C14	8
B10	3	C12	6		

PCM 555 – Coil Harness Circuit



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a - Coil Harness To Engine Harness Connector
b - 1 And 8 Coil Connector
c - 3 And 6 Coil Connector
d - 5 And 4 Coil Connector
e - 7 And 2 Coil Connector

There are 2 coil harnesses on the engine, one for each side of the engine. The harnesses are wired identically. The signal wire color for coils 1 and 8 is BLU, coils 3 and 6 is PUR, 5 and 4 wire is GRN, and 7 and 2 is RED The PNK wire is 12 volt power, the BRN wire is 5 volt power and the BLK wire is ground. If a possible problem is suspected in the ignition system, check for faults once with key ON and once with engine running. An EST Open will only register a fault in a key ON only state and an EST Short will only register with the engine operating.

A malfunction in the coil harness will set the fault of EST 1-8 Open or EST 1-8 Short.

Gen II I Cool Fuel System

System features:

- Single Integrated Module

  - Filter, pumps, pressure regulator and cooler, all in one unit

  - Fuel flows through filter before getting to lift pump

- More Reliable

  - Fewer components

  - Fewer fuel paths

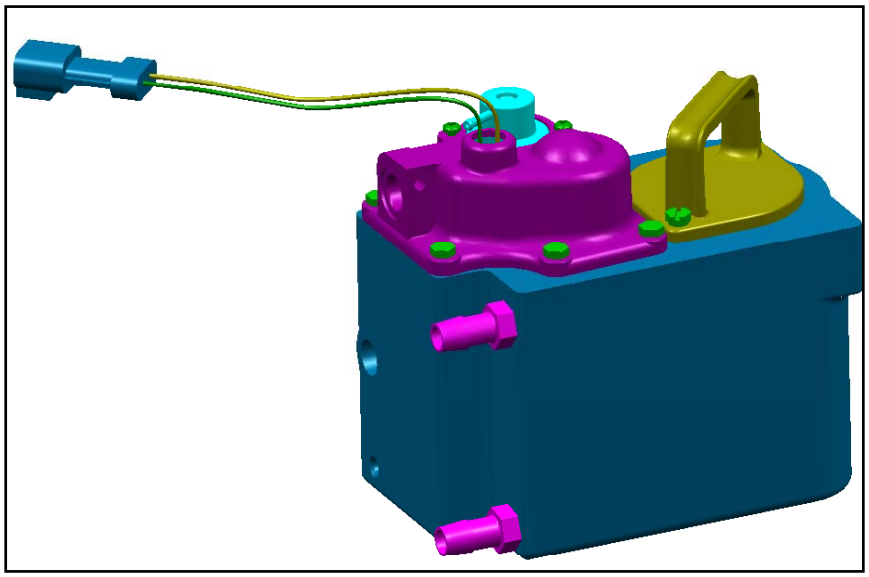
- Better Accessibility

- “Production-Friendly”

  - Eliminates installation of separate pre-filter at OEM

- Re-usable, consumer serviceable filter element

  - Pull element, dump water, re-install, continue voyage



This system will be standard on:

- Small-Block MPI V8 Bravo
- Small-Block MPI MIE
- Big-Block MPI Sterndrive
- Big-Block MPI MIE

It will not be available on:

- V6 Sterndrive
- Small-Block Ski
- Small-Block Alpha

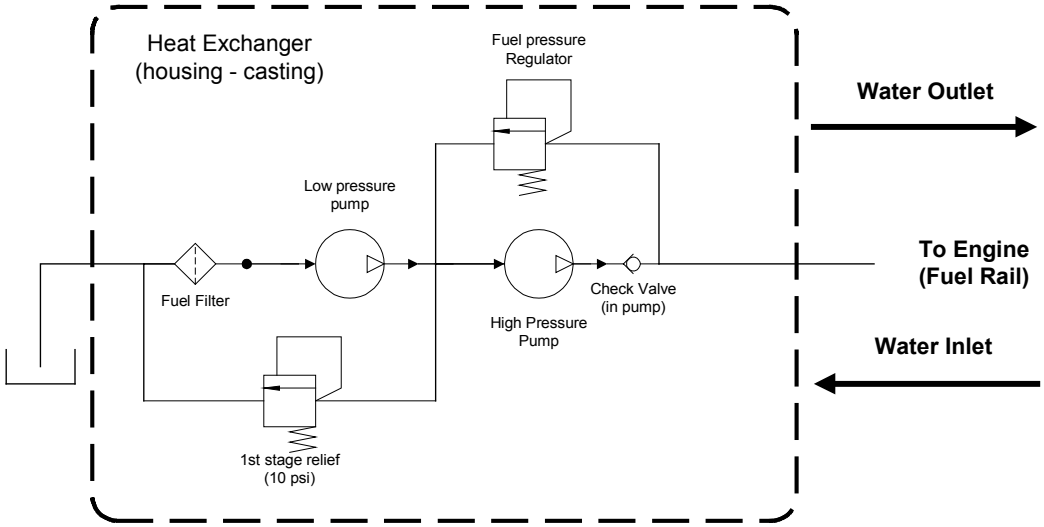
System Overview

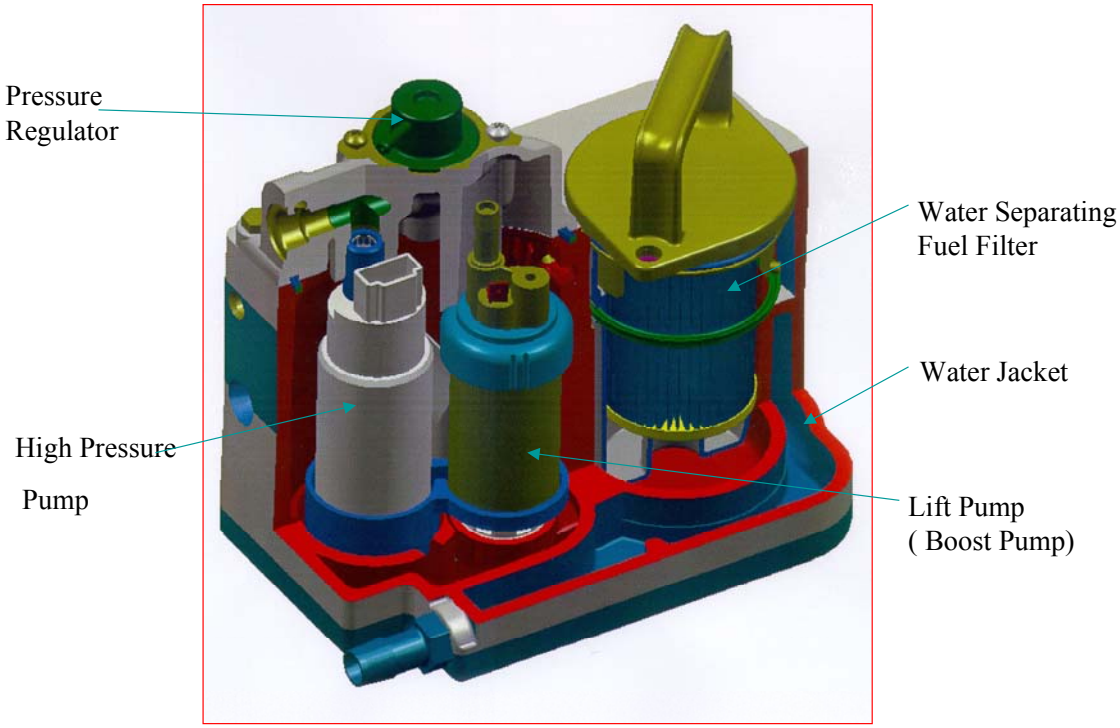
- Water Separating Filter Element
- 2 pumps – Lift & Pressure
  - Lift pump - Gerotor
  - Pressure pump – Turbine
- Fuel Pressure Regulator
  - New 288 kpa (~42 psi) regulator
  - O-rings seal between OD on regulator and ID in cover, rather than a face seal and return hose
  - Regulator dumps excess fuel to inlet side of pressure pump
  - Fuel pressure vs. flow characteristics differ slightly from Gen II, requires minor calibration changes
- Internal Low Pressure Relief Valve
  - Limits pressure across lift pump to 10 psi +/- 5 psi
  - Dumps fuel to inlet side of filter

System Module Features:

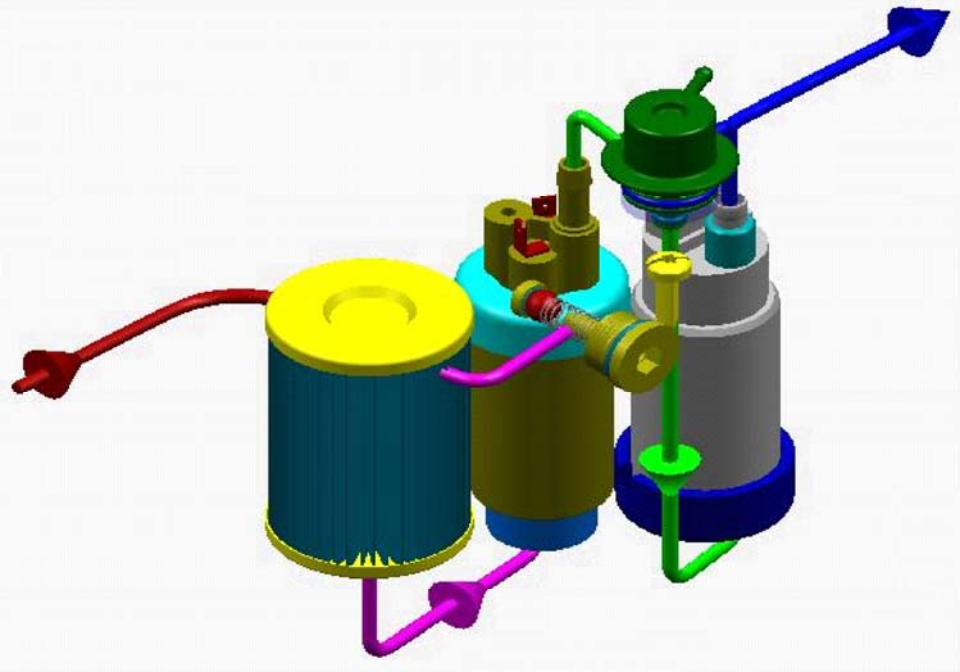
- Dual Pump Configuration
  - Improved Vapor Lock resistance compared to engines equipped with current boost pumps
- Corrosion Protection
  - Strontium-coated Internal water passage (same as outboards)
  - External housing e-coated
- Engine Installation
  - Low profile water connection, disconnect as required during engine installation
  - 3/8 NPTF thread inlet fuel connection
- Service Access
  - Modules located above front engine mount brackets in all applications
- Water Jacketed
  - Parallel water flow through module permits smaller module
- Pumps immersed in fuel and draw from bottom of cavity
  - Vapor rises to top of cavity, pumps always draw liquid
  - Reduced pump noise – not audible over engine at idle
- No external lines between filter, boost pump, pressure pump, and regulator
  - Eliminates 20 external fuel connectors
- 5 seals, not counting inlet and outlet
  - Filter cap – Modified SAE o-ring seal
  - Module Cover – Controlled-Crush quad ring
  - Pressure Regulator – Diametric o-ring
  - Pressure Relief Valve – Diametric o-ring
  - Harness – Fuel-tight pass-through fitting
- Self-Draining
  - Drains when seawater pump outlet is drained

System Overview:

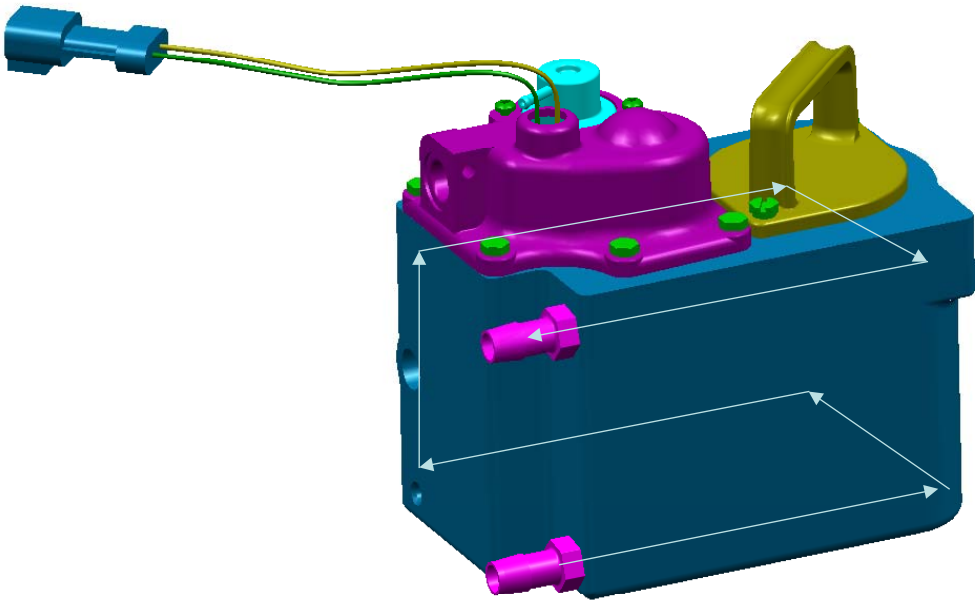




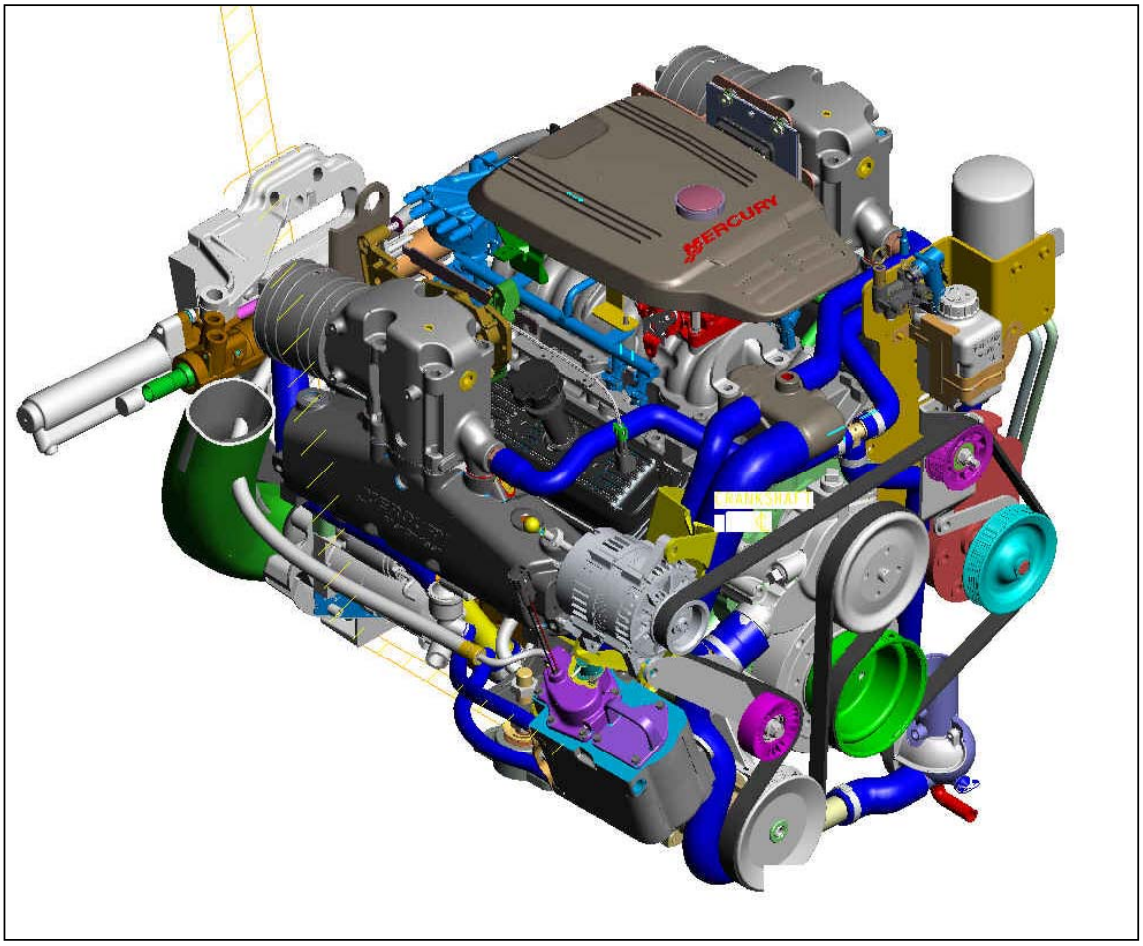
Fuel Flow Through the System

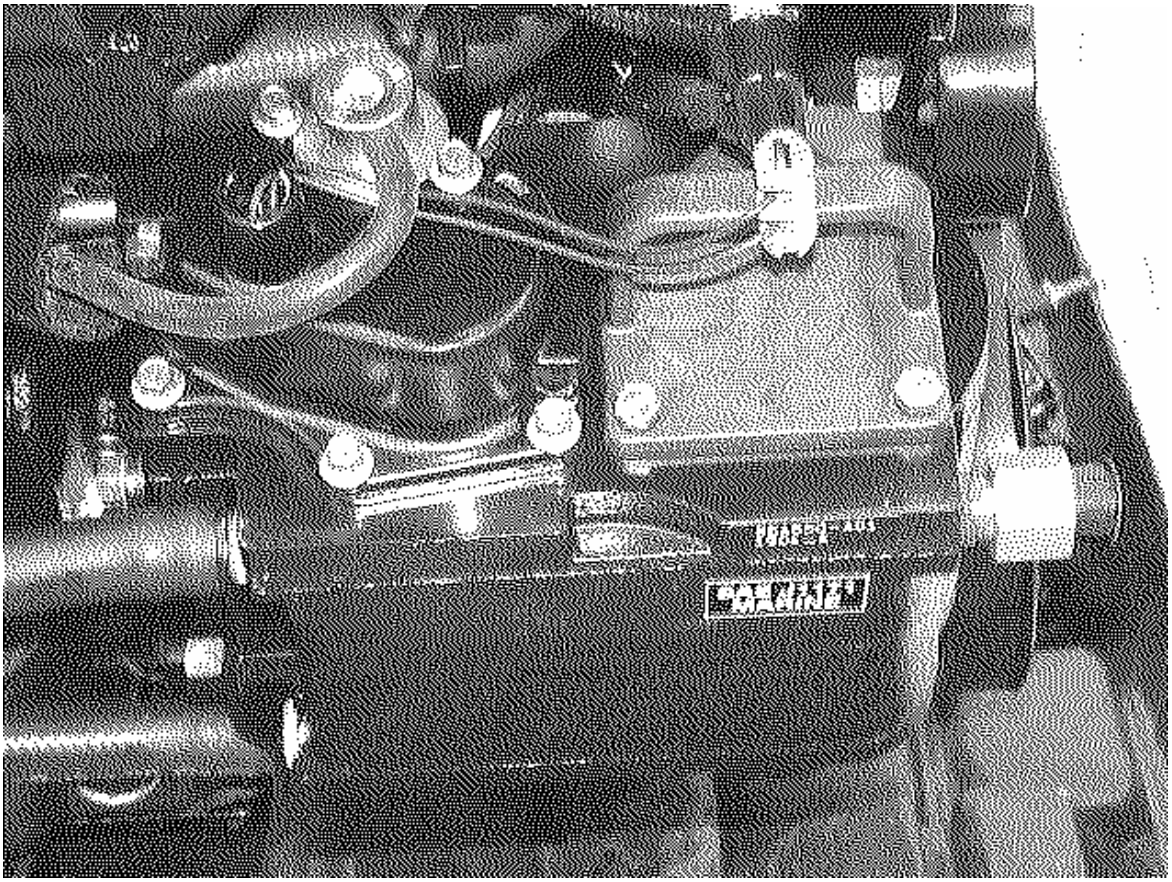


"2-Story" Water Flow Path



Cool Fuel III System - Mounted on Small-Block Engine





Gen III Cool Fuel Module

TOOLS & TECH TIPS

2

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MerCruiser EFI Tool List

Fuel System Tools:

Fuel pressure gauge set	91-881833A2
Adaptor fitting set (MT337-300 Snap-On)	91-803135
Replacement seals for adapter fittings (Snap-On)	
GM test port seal (large)	8-4814
MC Schrater test port seal (small)	8-4914
O-ring	8-4614
TBI adaptor fitting (with tire-valve fitting)	91-806901
Fuel line adaptor (with nipple fitting)	91-18078
Fuel line shut-off tool	91-805918A2
MPI injector noid light (Bosch connector)	J-34730A2/OTC #7188
GM TBI injector noid light	J-34730-400/OTC #7187
Fuel line disconnect tool set	J37088-A/J-41769/OTC#7660
$^{3}/_{8}$" fuel supply at rail	J-37088-1A or J-41769-1
$^{5}/_{16}$" fuel return plug at rail	J-41769-2
Portable 6.6 gal. Fuel Tank[1]	See current “MPP Acessories Guide” for selection of tanks
Cole-Parmer Digital PSIG Gage[2]	Model No. 68920-10
Stevens Instruments Gearcase Pressure Tester[3]	S-34
Fuel quality testing kit	J-39383A/OTC#7670
Fluke Pressure/Vacuum Transducer Module	PV-350 (Fluke #)

Electrical System Tools:

DMT 2004 multi-meter Set (10 Mega-ohm impedance)		91-892647A01
Clamp-on ammeter probe (for any standard DVOM)		91-802650
DVA adaptor (for any standard DVOM)		91-89045-1
EFI 12v test light[4] (unpowered)		J-34142-B
IAC noid light	(Rinda #94016)	OTC #3053S
EFI test lead set		Rinda #94025
GM style harness test leads		J-35616-A
Packard connector repair Kit		J-38125-B
Quicksilver Electrical Hardware Kit (bullet connectors)		86-813937A2
Quicksilver Crimping Pliers (packard style)		91-808696
Quicksilver Harness Seal Kit		91-881814A1
Snap-on Terminal Tool Kit[5]		TT-600
Remote Starter Switch		91-52024A1

Ignition System Tools:

Kilo-Volt meter (Snap-On)	MT2700 DIS/KV
Air gap spark tester (single 1/2 inch gap)	91-63998A1
Air gap spark tester (8 adjustable gaps)	91-850439T1
Timing jumper plug (jumps A & B at DLC)	91-805747A2
Continuity light (1.5v self-powered)	J-21008-A
Timing light[6]	Locally available

General Diagnostic Tools:

Hand vacuum pump (Mity-Vac or equivalent)	J-23738-A/OTC #7059
Rinda CodeMate (winky-blinky)	94008
Rinda MerCruiser scan tool (current software version 4.0)	94050m
Software update for scan tool (version 4.0)	94056
ECM/PCM 555 adapter cable	64006
Update for scan tool (software and cable)	94056
Rinda Diacom PC software and cable (Windows Version)	94010m
Quicksilver DDT (digital diagnostic terminal)	91-823686A2
MerCruiser DDT cartridge (current software version 2.0)	91-803999
SmartCraft DDT cartridge (version 1.3)	91-880118-003
MerCruiser DDT adaptor cable (DLC and injector connectors) (MEFI ECM's)	84-822560A2
SmartCraft MerCruiser DDT adaptor cable (ECM/PCM 555 ECM's)	84-822560A13 or, 84-822560A5 and 84-822560T12
OTC replacement "boot" for DDT	OTC #3305-30
OTC printer for DDT	OTC #3285
OTC printer cable for DDT (25-pin serial port)	OTC #212536
OTC PC cable for DDT (9-pin serial port)	OTC #212535
Standard manifold vacuum gauge[7]	Locally available
Mechanics stethoscope[8]	Locally available
3" of 5/32" I.D. clear vinyl hose with a 5/32" Tee[9]	Locally available
5/16" or 3/8" clear vinyl hose with a hose barb on one end[10]	Locally available

Footnotes:

1. Used to provide source of known quality fuel or to bypass boat fuel system as required. Should be used only by trained Marine Technicians and only for short-term diagnostic purposes.
2. Used for both pressure and vacuum tests. "Gauge Guard" is not necessary. Reads from absolute zero to 199.9 PSI.
3. Can be used to apply slight pressure to test fuel systems for leaks.
4. Must have a minimum of 100 milliamps draw, but not more than 300 milliamps.
5. Contains six tools for removal of terminal pins from harness blocks
6. Such as the Ferret 80 series from Stevens Instruments, OTC and other suppliers.
7. Such as Snap-On MT14GS15SV
8. Used to listen to fuel injectors, air leaks, fuel pump(s) and IAC operation.
9. Used to check fuel pressure regulators for leakage and to attach vacuum gauge.
10. Used to check the VST vent line for the presence of raw fuel.

Tool Manufacturers

Cole_Parmer Instrument Co.
800-323-4340
847-549-7600
847-247-2929 FAX
847-549-1700 International FAX

Rinda Technologies
4563 N. Elston Ave.
Chicago, IL 60630
773-736-6633
Fax: 773-736-2950

OTC Tools/SPX Corporation
655 Eisenhower Drive
Owatonna, Minnesota 55060
800-533-0492
Fax: 800-283-5665

Fluke Corp.
P.O. Box 9090
Everett, WA 98206-9090
800-443-5853

Kent-More Tools/SPX Corporation
(J-tools)
29784 Little Mack
Roseville, MI 48066
800-345-2233
Fax: 810-578-7375

Stevens Instruments
111 Greenwood Avenue
Waukegan, Illinois 60079-9375
847-336-9375
Fax: 847-662-6808

SPX Service Repair
2300 Park Drive
Owatonna, MN 55060
800-344-4013

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You know from your own marine service experience that outboard ignition systems are very noisy with lots of RFI interference. Our new DMT 2000A Digital Tachometer/Multi-meter represents real breakthrough technology in the marine service industry. It's the only meter on the marine market today designed to read accurately in high RFI environments. The only meter that measures RPM on both 2- and 4-cycle marine engines while recording maximums and minimums simultaneously!

Give your service personnel the latest in innovative marine technology, the DMT 2000A Digital Tachometer/Multi-meter, from Mercury Marine. Order today!

Complete the order form below and we guarantee that your marine service life will get just a little easier!

DESCRIPTION	PART NUMBER
DMT 2000A Complete Kit	**91-854009A 3**
Replacement Components:	
8 ft. (2.4m) inductive pick-up	91-854010 1
Temperature probe	91-854011 1
Replacement ferrite core	91-854012
Interface module	91-854013 1
Hard carrying case	91-854014 1
User's guide	91-854015 1
Test Leads	91-802651
Optional Accessories:	
8 ft. (2.4m) inductive pick-up extension	**84-854016 T**
Clamp-on Current Probe	**91-802650 1**
Direct Voltage Adaptor	**91-89045 1**

Order on MIDAS or contact Quicksilver Sales at:

In USA: Phone (920) 929-5589 Fax (800) 457-8736

Quicksilver Marine Parts and Accessories • Products of Mercury Marine • Fond du Lac, WI 54936-1939 USA

Mercury DMT 2000A FAQ'S

- **Q.** What battery does the DMT 2000A take and where is it located?
  A. The DMM requires a 9 volt alkaline battery and is located inside the meter at the bottom of the case inside.

- **Q.** The DMT 2000A keeps using up batteries.
  A. The instrument has a "sleep mode" and not auto power off. Since you may do long term recording there is still a battery draw on the system and it will go dead. This is a normal condition and must be turned off manually each time.

- **Q.** What sizes are the fuses and what are the part numbers?
  A. There are 2 fuses. The small fuse is a 2 amp (MT586-2) and the large fuse is a 10 amp (MT586-3).

- **Q.** The display starts loosing segments and has unusual figures in cold weather, what could be wrong?
  A. Check your operating temperature. It's common for an LCD to freeze below 32 degrees F.

- **Q.** The meter reads "Ouch" is it broken?
  A. No. On Ohms the meter will reach Ouch to signify infinite Ohms. On the temperature selection it means the thermocouple is not inserted or has an open circuit on the thermocouple. Also when in the manual ranging mode the meter will read "Ouch" to indicate the range needs to be increased.

- **Q.** The temperature reads "Ouch" and I just replaced the thermocouple, is there a field fix?
  A. Yes. Since the temperature and mA range share the 2 amp fuse, check for this fuse failure. Also check for thermocouple continuity.

- **Q.** What is the location of the fuses?
  A. The rubber boot should be removed and the 3 screws taken off the back cover. Next "split" the case and remove the back cover. Gently pry the circuit board out of the front case. As you are looking at the circuit board (selector facing you) the 10 amp fuse is on the left side and the 2 amp is on the right.

- **Q.** Can you check the fuses without taking the case apart?
  A. Yes. To check the 10 amp fuse, turn the selector to the "temperature setting" and use one test lead to bridge the common and temperature terminals. The display should read close to room temperature. To check the 2 amp fuse, set the selector to the "diode" setting and bridge the common and Ohms terminals. The display should read very close to zero Ohms if the 2 amp fuse is good.

- **Q.** Does the DMT 2000A have Auto Power Off and Auto ranging?
  A. Yes. The meter will shut off after approximately 30 minutes (this is only a sleep mode, there is still a power draw). It is automatically in auto ranging. The manual ranges can be selected using the "Range" button otherwise it is always in auto ranging.

- **Q.** While using the Inductive RPM mode on small engines the display "hunts" or reads higher than actual RPM, or even locks up the display. What can be done?
  A. Use the RPM 1 signal conditioning module.

- **Q.** Using the RPM mode the RPM's seem to be doubled, why?
  A. On some late model ignition systems, with a "waste spark" system, the plug fires twice per cycle. Simply switch to "2 Stroke" to obtain the correct readings.

- **Q.** While using the Ohms range the display is not stable.
  A. Make sure the test leads are tight in the meter. Also clean the probe ends with a mild abrasive for best contact.

- **Q.** With the test leads touched together the display reads 0.3 Ohms.
  A. This is the actual value of the test lead resistance. To zero the display, for accurate low Ohms, touch the leads together and depress the “Rel” button to zero.

- **Q.** On the Inductive RPM function how do I set the number of cylinders?
  A. It is not necessary when using this technique to measure RPM.

QUICKSILVER®
MARINE PARTS AND ACCESSORIES

91-854009A 3
DMT2000A Digital Tachometer/Multi-Meter Kit

Meter Connections and Hook-up

Interface Module Battery Check

IMPORTANT: The internal battery for the Interface Module (P/N 91-854013-1) MUST BE in good working condition to obtain stable tachometer readings. A low battery voltage will give erratic readings.

PROCEDURE:

1. Plug interface module into **DMT2000A** meter. Refer to **Figure 1-1**. Red lead plugs into the **VΩHz** port and the Black lead into the **COM** port.
2. Position rotary function selector to DC Voltage $\overline{\underline{\mathbf{V}}}$ position.
3. Reading should be 2.8 Volts or higher.
4. Replace interface module battery if reading is below 2.8 Volts.

Figure 1-1: DMT2000A and Interface Module

Tachometer - Secondary Inductive Pick-Up

IMPORTANT: Use the "2STR" range for tachometer testing on the Mercury/Mariner 4-Stroke Outboards. Refer to DMT2000A information in this User's Manual for additional information and instructions.

PROCEDURE:

1. Plug interface module into **DMT2000A** meter, refer to **Figure 1-2.** Red lead plugs into the **VΩHz** port and the Black lead into the **COM** port.
2. Plug Inductive Clamp (P/N 91-854010), into interface module with lead marked "+" to Red port and lead marked "–" to Black port.
3. Position rotary function knob to IP (RPM Inductive).
4. Depress "RANGE" button to select "2STR" or "4STR" **See important above**.
5. Clip Inductive Clamp to high tension spark plug lead.
6. Read RPM on **DMT2000A** Display.

Figure 1-2: DMT2000A With Filter and Inductive Clamp

Direct Voltage Adapter (DVA) - Optional Accessory (P/N 91-89045)

PROCEDURE:

1. Plug Direct Voltage Adapter into **DMT2000A** meter, refer to **Figure 1-3.** Red lead plugs into the **VΩHz** port and the Black lead into the **COM** port.
2. Plug Test Leads into Voltage Adapter with Red lead into Red receptacle and Black into Black receptacle.
3. Position rotary function knob to DC Voltage scale, indicated by $\overline{\overline{V}}$.
4. Read DC Voltage on **DMT2000A** Display.

Figure 1-3: DMT2000A with Direct Voltage Adapter and Test Leads

Attaching Alligator Clips

PROCEDURE:

1. Screw alligator clips over ends of probes with Red to Red and Black to Black. Refer to **Figure 1-4 Attaching Alligator Clips.**
2. Tighten alligator clips finger tight.

Figure 1-4: Attaching Alligator Clips

Temperature Probe

PROCEDURE:

1. Plug small Thermocouple Plug into Thermocouple Probe with “–” to “–” and “+” to “+”, refer to **Figure 1-5.**
2. Plug Thermocouple Probe into **DMT2000A** with “+” side to **VΩHz** port, refer to **Figure 1-6.**
3. Position rotary function knob to **TEMP** position. Use FUNCTION key to toggle between °C and °F.
4. Read temperature on **DMT2000A** Display.

Figure 1-5: Thermocouple Plug

Figure 1-6: Thermocouple to Meter

Clamp-On Current Probe - Optional Accessory (P/N 91-802650)

IMPORTANT: Refer to Users Guide supplied with Clamp-On Current Probe for proper testing procedures.

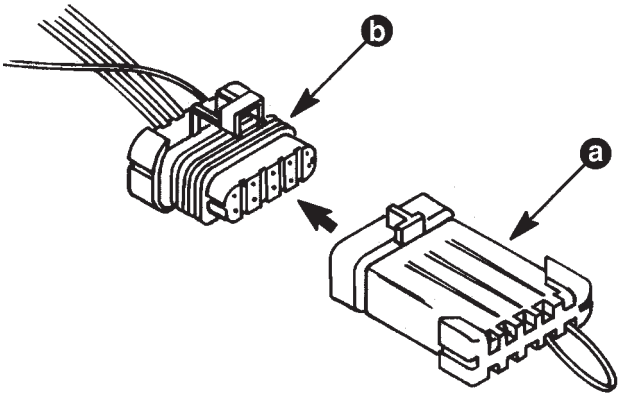
PROCEDURE:

1. Plug end of Clamp-On Probe with side marked "+" into **VΩHz** port and side with "–" to **COM** port, refer to **Figure 1-7 and Figure 1-8:** Clamp-On Probe to Meter.
2. Position rotary function knob to DC Voltage scale, indicated $\overline{\overline{V}}$.
3. Read DC Voltage on **DMT2000A** Display.

Figure 1-7: Clamp-On Probe

Figure 1-8: DMT2000A with Clamp-On Current Probe

P/N 91-805747A2 Timing Tool for MerCruiser EFI Engines



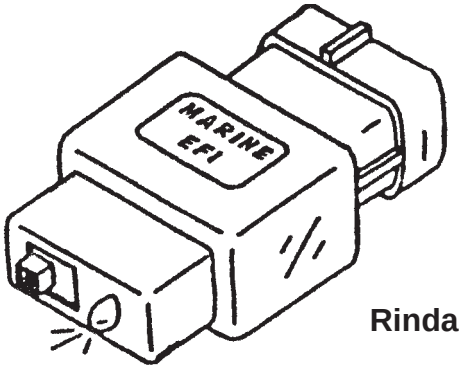
71839

a - Timing Tool
b - DLC Connector

CODEMATE™

Marine EFI Code Reader (Rinda)

CodeMate serves as both an EFI problem indicator and a spark timing service tool. The device connects to the DLC in a matter of seconds and alerts the boat owner or technician when EFI problems are detected. CodeMate allows diagnostic trouble codes (DTC's) to be read and when used with a timing light, allows the technician to verify/set the base ignition timing.



Rinda #94008

Available from:
Rinda Technologies, Inc. Chicago, IL
Telephone: (773) 736-6633
Fax: (773) 736-2950

Scan Tools

Older Software and Newer EFI Systems

Older scan tool software for the Quicksilver Digital Diagnostic Terminal (DDT) and MerCruiser/Rinda scan tools will not be able to read the information coming from either the newer MEFI's or the ECM/PCM 555 ECM's. If you use the wrong software you will get an "error" message on the display of the DDT scan tool, or you will get incorrect information from a MerCruiser/Rinda scan tool.

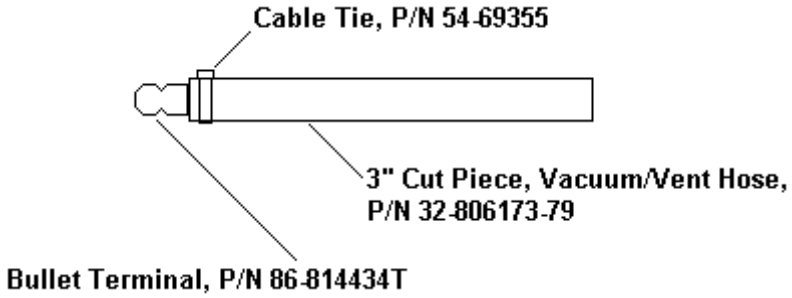
Quicksilver DDT Scan Tool (New Cartridge)

The DDT will need MerCruiser cartridge, version 2.0 (P/N 91-803999), to read MEFI-3 ECM's. This cartridge can also read data from Thunderbolt 5 ignition used on carbureted models. See Service Bulletin 2001-2. A second cartridge will be required to read ECM/PCM 555 controllers. Order SmartCraft DDT cartridge, version 1.3 (P/N 91-880118-003).

Tech Tips

The following “Tech Tips” are ideas that you may find useful.

1. **Cylinder Balance Test Tool**



   Construct eight tools as shown above. Insert a hose end into each spark plug wire tower on HVS (distributor) cap and insert bullet terminal end into corresponding spark plug wire boot. Start engine. By grounding each hose in turn with a 12v test light, you will be able to tell if each cylinder is functioning.

2. **Remote Starter Switch, PN 91-52024A1**

   Probably the easiest way to attach the remote starter switch is to hook one lead to any convenient power source, such as either side of the circuit breaker or the slave solenoid **red-purple** terminal, and the other lead to the slave solenoid **small yellow-red** terminal.

⚠CAUTION

DO NOT attach the remote starter switch to both large terminals of the slave solenoid. If this is done, pressing the switch will bypass the slave solenoid and all starting current will flow through the switch and its attaching wires. This can cause equipment damage and personal injury.

3. When it is necessary to probe circuits, **NEVER** puncture wiring insulation as this can permit moisture to enter and result in circuit failure due to corrosion. Care should also be exercised when probing terminals in harness blocks. Insertion of a probe that is too large can spread the terminal, preventing good pin to pin contact when the harness block is reconnected. Use of the GM style test leads, PN J-35616-A, and/or the Rinda EFI test lead set, PN 94025, can prevent both these problems.
4. When an engine won’t start or starts but runs poorly, be sure to not forget to check for water in the fuel and for old, deteriorated fuel. If either of these conditions is suspected, use of a portable outboard tank can be very helpful.
5. The PG (**P**ermanent magnet, **G**ear reduction) starters used on all current sterndrive engines are highly efficient. Because of this, a battery that is too weak to provide sufficient voltage at the ECM/PCM to start an engine can, at times, turn it over so fast that the battery is not immediately suspected. Don’t forget to check battery voltage when troubleshooting a “hard start” complaint.
6. The crank position sensor (CPS), fuel pump and injectors on ECM 555 equipped engines can be easily checked. Remove the CPS from the engine. With the harness attached to the CPS and with the ignition switch on, rapidly pass the flat side of a screwdriver blade close to the sensor tip. A scan tool will show RPM, the injectors will fire and the fuel pump will run if the sensor is functioning.

DIAGNOSTICS

3

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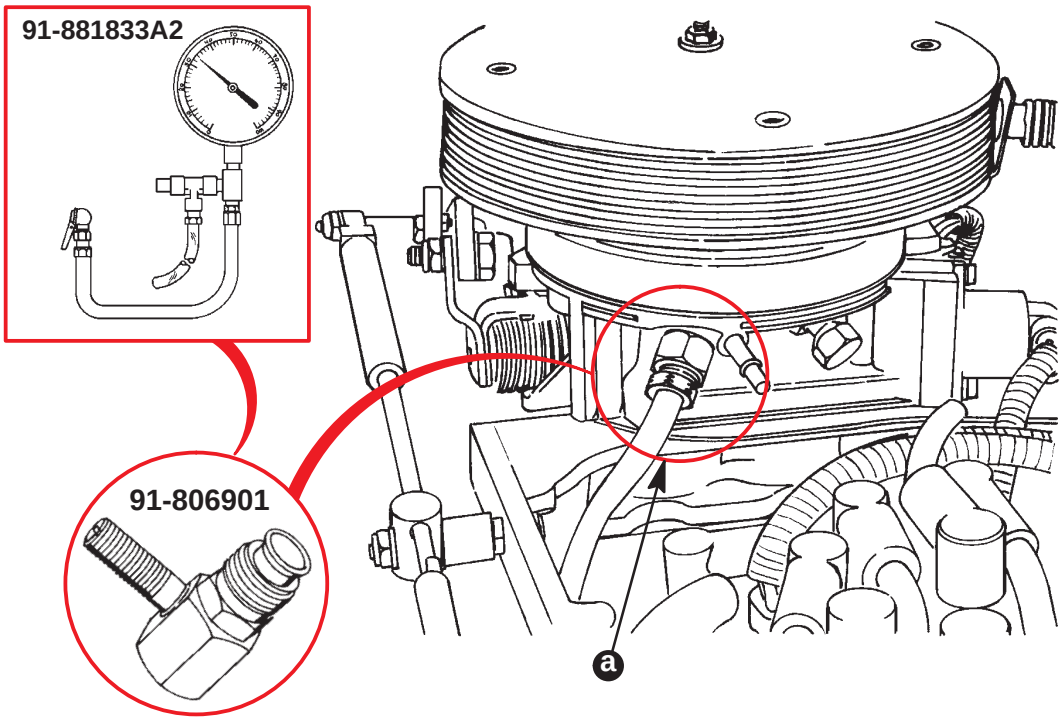
Testing Fuel System Pressure on EFI Throttle Body Injection Systems



a - Remove Fuel Line from Throttle Body Unit and Install Fuel Fitting Connector P/N 91-806901. Connect Fuel Pressure Gauge Kit, P/N 91-881833A2 (S.S. from 91-16850A7), to test system pressure.

Fuel Pressure Test Gauge Adaptor Fittings

The following information is contained in revised Service Bulletin 97-24.

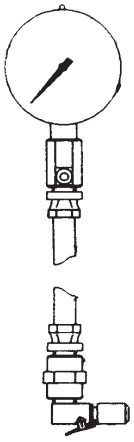
1998-2000 MCM/MIE 7.4L MPI (L29) uses a different size and type of 'test port' valve on it for checking the fuel pressure at the fuel rail. The older Fuel Pressure Gauge Kit (P/N 91-16850A 2) will not attach to this valve. A new kit has superseded this kit and it contains 2 fittings so it will fit both types of 'test ports' and a TBI pressure valve to allow the gauge to connect to TBI engines.

Quicksilver will also sell an Adapter Kit that can be purchased to update the older 91-16850A 1, 2, 3 kit. This kit comes with both size 'test port' valve adapters and instructions on how to fit it to the older gauge kit.

91-881833A 2	Fuel Pressure Gauge Kit. Kit contains Adapter Kit and TBI Pressure Valve.

To update older 91-16850A 1, A 2, or A 3 Fuel Pressure Gauge Kits, order the following:

91-806901	TBI Pressure Valve. Allows older Gauge Kits to connect to TBI engines.
91-803135	Adapter Kit. Allows older Gauge Kits to connect to either type of 'test port' valve.



Testing Mechanical, or Electric Fuel Supply Pump (used on VST models)

Precautions

⚠ WARNING

Always disconnect battery cables from battery BEFORE working on fuel system to prevent fire or explosion.

⚠ WARNING

Be careful when changing fuel system components; gasoline is extremely flammable and highly explosive under certain conditions. Be sure that ignition key is OFF. DO NOT smoke or allow sources of spark or flame in the area while changing fuel filters. Wipe up any spilled fuel immediately.

⚠ WARNING

Make sure that no fuel leaks exist before closing engine hatch.

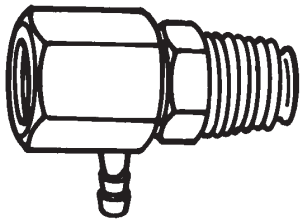
⚠ CAUTION

DO NOT operate engine without cooling water being supplied to seawater pickup pump, or pump impeller will be damaged and subsequent overheating damage may result.

NOTICE

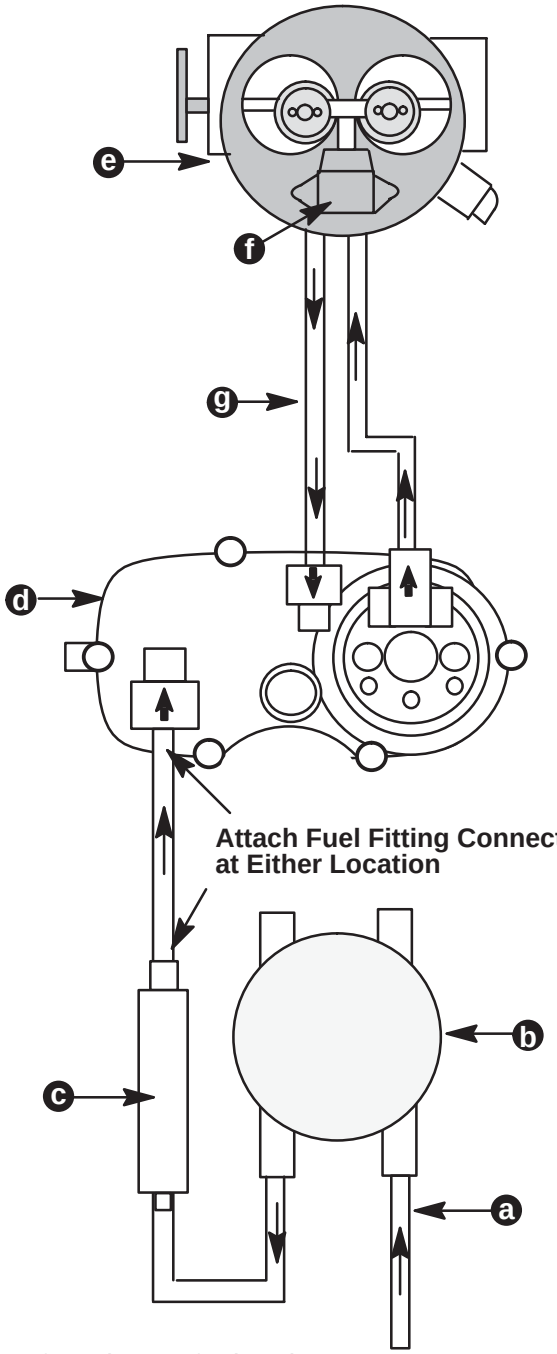
BEFORE proceeding, refer to “Precautions”.

1. Disconnect battery cables from battery.
2. Remove fuel line from outlet side of mechanical, or electric fuel supply pump, or from inlet side of VST tank.
3. Install Fuel Pressure Connector (91-18078) to fuel supply pump, or VST tank and reinstall fuel line. Tighten connector and fuel line securely.
4. Connect fuel pressure test gauge (0-15 psi) to connector.
5. Reconnect battery cables, start engine, and run at 1800 RPM. If engine will not start, crank engine to obtain reading.
6. Fuel pressure should be within specifications (7-9 psi). If not, replace fuel pump.

Fuel Fitting Connector	91-18078
Description: Connects fuel pressure gauge to fuel system, installed between fuel supply pump and VST unit.	 73469

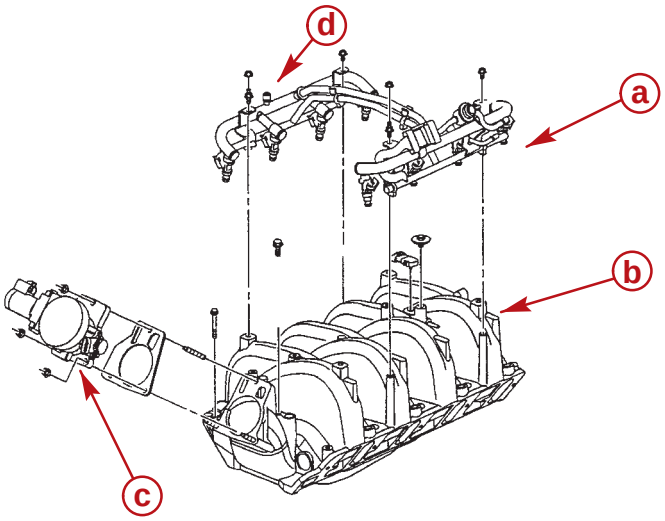
Testing Mechanical, or Electric Fuel Supply Pump (used on VST models) (cont.)

Throttle Body Injection With Vapor Separator Tank (VST)



a - Fuel line from boat's fuel tank
b - Water separating fuel filter
c - Supply pump (mechanical or electric)
d - Vapor separator tank
e - Throttle body with 2 fuel injectors
f - Fuel pressure regulator
g - Return line to vapor separator tank

Testing Fuel System Pressure on EFI Systems



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a - Fuel Rail Assembly
b - Intake Manifold
c - Throttle Body
d - Fuel Pressure Test Port

Testing Boost Pump (If so equipped)

Precautions

⚠ WARNING

Always disconnect battery cables from battery BEFORE working on fuel system to prevent fire or explosion.

⚠ WARNING

Be careful when changing fuel system components; gasoline is extremely flammable and highly explosive under certain conditions. Be sure that ignition key is OFF. DO NOT smoke or allow sources of spark or flame in the area while changing fuel filters. Wipe up any spilled fuel immediately.

⚠ WARNING

Make sure that no fuel leaks exist before closing engine hatch.

⚠ CAUTION

DO NOT operate engine without cooling water being supplied to seawater pickup pump, or pump impeller will be damaged and subsequent overheating damage may result.

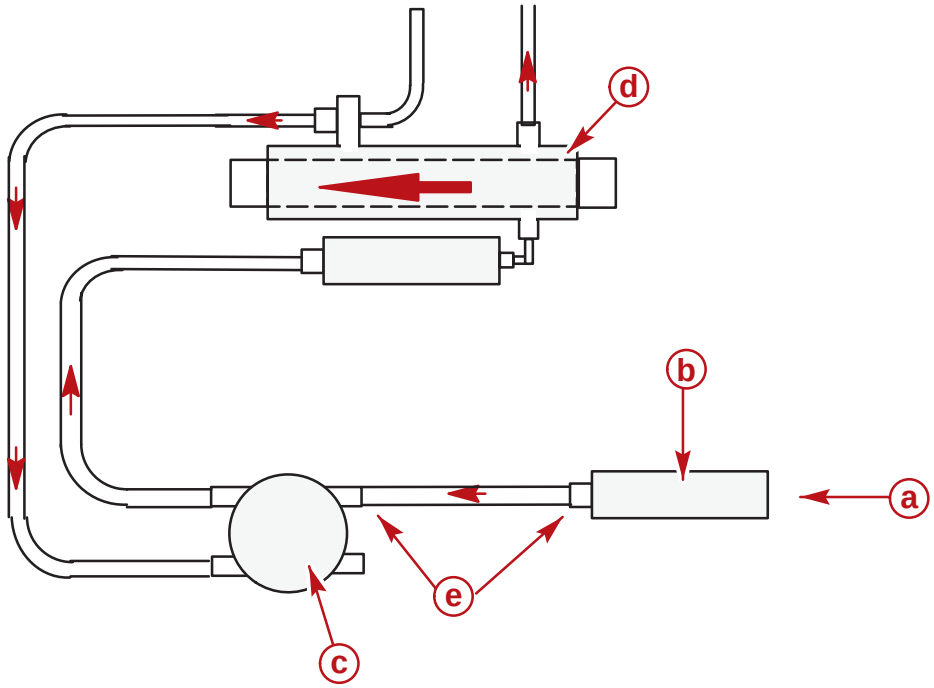
NOTICE

BEFORE proceeding, refer to “Precautions”.

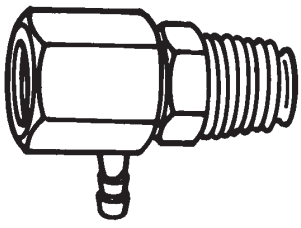
1. Disconnect battery cables from battery.
2. Remove fuel line from outlet side of boost pump, or from inlet side of water separating fuel filter.
3. Install Fuel Pressure Connector (91-18078) to boost pump, or water separating fuel filter and reinstall fuel line. Tighten connector and fuel line securely.

4. Connect fuel pressure test gauge (0-15 psi) to connector.
5. Reconnect battery cables, start engine, and run at 1800 RPM. If engine will not start, crank engine to obtain reading.
6. Fuel pressure should be within specifications (7-9 psi). If not, replace fuel pump.

NOTE: *If the screen on the inlet side of the boost pump is clogged, the boost pump pressure will be low.*

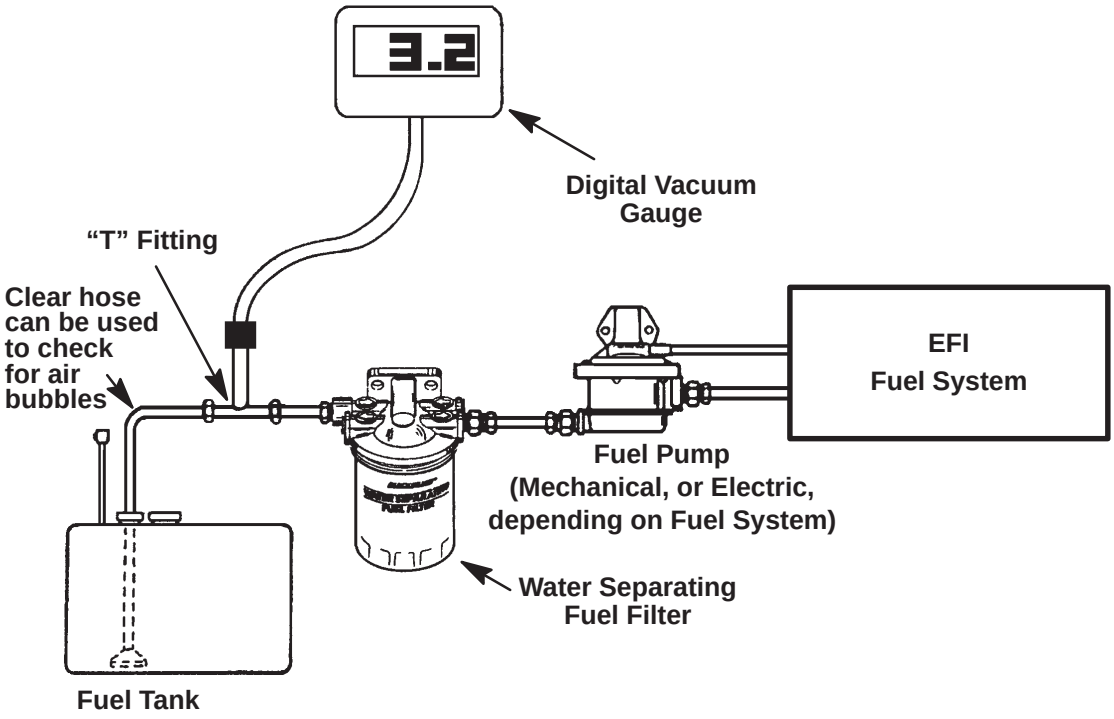


a - Fuel from Tank
b - Fuel Boost Pump
c - Water Separating Fuel Filter
d - Fuel Cooler
e - Install Fuel Fitting Connector (91-18078) at Either Location

Fuel Fitting Connector	**91-18078**
Description: Connects fuel pressure gauge to fuel system, installed between fuel supply pump and VST unit.	 73469

Checking for Restrictions/Vapor Lock Problems in Fuel Delivery Systems

If there are any restrictions in the fuel delivery system the engine may experience vapor lock and other driveability problems. Fuel supply problems can be checked by using a vacuum gauge on a water separating fuel filter fitting port. Installing it on the inlet side will check the fuel tank to filter supply line and hardware (anti-siphon valve, fuel fittings, etc.). Installing it on the outlet side will check the supply line, hardware and the filter. If the outlet vacuum reading is higher than the inlet reading, the filter is clogged. If both readings are high then inspect the fuel tank, supply line and hardware. Check for trash in the tank (blocking the pick-up), clogged fuel filter screens on the end of pick-up tubes in the tank, clogged in-line fuel filters, blocked off fuel tank vent, bent pick-up tube, dirt and debris in fuel fittings, wrong size fuel fittings (undersize connector fittings, undersize fuel shut off valve passages, etc.), undersize fuel line, or a malfunctioning anti-siphon valve.


3.2
Digital Vacuum Gauge
"T" Fitting
Clear hose can be used to check for air bubbles
EFI Fuel System
Fuel Pump (Mechanical, or Electric, depending on Fuel System)
Water Separating Fuel Filter
Fuel Tank

There is a MerCruiser specification for allowable vacuum, when measured at the inlet side of the engine mounted MerCruiser Water Separating Fuel Filter or if there is none mounted on the engine, at the inlet side of a fuel pump. Use a digital vacuum gauge (an analog gauge may not give accurate enough readings at these low levels) that reads in either in. Hg. (inches of mercury), or kPa (kilopascals).

The specification is: **2 in. Hg. (7 kPa) maximum at: idle, 3000 rpm, full throttle and then back at idle rpm (check at each point).**

Any anti siphon valve or restriction that causes a higher reading can contribute to vapor locking and other driveability problems. In hot weather, if you see 0 vacuum on the gauge and the engine is still running poorly, check the inlet fuel line to ensure that a good solid flow of fuel is in the line, instead of a mixture of fuel and vapors. If the vacuum is too high, try a less restrictive anti siphon valve. Restrictive anti siphon valves can cause vapor locking conditions.

Going to the next larger Inside Diameter fuel lines and fittings can help lower the vacuum also. This larger diameter ID can also help correct vapor locking conditions. An example is shown below.

5/16 in. (8 mm) Fuel Line ID	5.5 in. Hg or (17.8 kPa)	Too high.
3/8 in. (9.5 mm) Fuel Line ID	2.5 in. Hg or (8.2 kPa)	Too high.
1/2 in. (12.5 mm) Fuel Line ID	0.8 in. Hg or (2.7 kPa)	Good

See MerCruiser Service Bulletin 99-7 (Rev. 1/01) for information on gasoline engine vapor locking.

Delco EST Ignition Troubleshooting

Erratic Spark Symptoms

1. If the erratic spark occurs only when the engine is warm, or is especially bad on warm days, remove the ignition module and make sure that plenty of thermal transfer compound is present on the module's base. The module will misfire if it is too hot.
2. Verify that the purple power lead (carbureted) or red power lead (EFI) to the ignition coil is holding steady battery voltage during the erratic spark (misfiring) event. If not, check the key switch and safety lanyard switch for loose connections or internal failure.
   a. Try isolating the boat harness with a shop test harness (the 3-foot MerCruiser harness – part #84-812475A3 and MerCruiser ignition switch assembly – part #54212A7). If the problem disappears, the problem is in the boat harness, not the MerCruiser engine harness.
   b. There are several splices in the purple lead on almost all MerCruiser engines, so it may be necessary to go into the engine harness to find the loose connection. On an EFI engine, ignition coil power comes from the system relay.
3. If the purple (or red) power lead to the coil holds steady voltage, carefully flex the pink and brown harness (between the coil and the ignition module) while the engine is running. If the engine runs better or quits, replace the harness between the coil and ignition module. This is usually because the filter in the pink lead has failed.
4. If erratic spark is still present, isolate the gray (carbureted) or white (EFI) tach lead at the negative side of the ignition coil. Use a suitable jumper lead to jump the purple (or red) lead to the ignition coil and leave the tach lead disconnected. Kent-Moore Jumper Lead Kit #J-35616 works well, or you can cut the gray (or white) tach lead near the ignition coil and install a bullet connector from Quicksilver connector kit part #86-813937A2. If the engine now runs better, tach lead is partially shorted to ground in the engine harness, boat harness or in the tach itself.
5. Alpha EFI "MEFI-1" Models – if erratic spark is still present, bypass shift interrupt switch with the Bravo jumper lead (P/N 805592A1). If the engine now runs better, replace the shift interrupt switch.
6. If erratic spark is still present, troubleshoot the secondary system with a Kv meter.

No Spark Troubleshooting

1. Visually check the ignition coil for melted plastic on its outer case. If the case is melted, the tachometer lead (gray or white) is shorted to ground somewhere. Isolate and repair before replacing the ignition coil.
2. Make sure that battery voltage is present at the purple power lead (carbureted) or red power lead (EFI) at the ignition coil. If not, isolate and repair the problem in the engine or boat harness.
3. Isolate the gray (carbureted) or white (EFI) tach lead at the negative side of the ignition coil as described in the previous section, step 4. If spark is now present, the tach lead is shorted to ground in the engine harness, boat harness or in the tach itself.
4. Disconnect the 4 pin connector from the ignition module.

   Carbureted models: if spark is now present, the shift cut-out switch is stuck on or shorted closed. Replace the switch and retest.

   EFI models: if spark is now present, the ECM is sending bypass voltage to pin "B" of the ignition module and it is not supposed to. The EFI system will have to be diagnosed at this time, as there is not a problem with the EST system.

5. Disconnect the 2-pin connector from the ignition module. With the Key ON, check for battery voltage at both the pink and brown terminals of the harness.
   a. If there is not battery voltage at the pink terminal, replace the 2-wire harness as the filter is most likely blown open.
   b. If there is not battery voltage at the brown terminal, replace the ignition coil as the primary windings have most likely melted open (because of a shorted tach lead).
   c. Reconnect the 2-pin connector to the ignition module when finished.
6. If spark is still not present, remove the distributor cap and check the pickup coil for resistance and short-to-grounds. Resistance across the green and white leads must be 500-1500 ohms (750-850 preferred) and the reading must be steady. Resistance between the green lead and the distributor frame must be “infinity” and resistance between the white lead and the distributor frame must be “infinity”. If any of these readings differ from specifications, replace the pickup coil.
7. Verify that the timer core is still magnetic. This is the part that rotates above the pickup coil.
8. If spark is still not present, you will need to “false trigger” the module to determine if it is opening and closing the primary circuit. Proceed as follows:
   a. If still isolated, reconnect the tach lead to the ignition coil. Connect a voltmeter to the gray tachometer lead bullet connector (near the ignition coil). Set the meter to read DC volts. Connect an air gap tester from the coil’s secondary terminal to ground.
   b. Remove one of the ignition module mounting screws and loosen the other. Rotate the module out from the distributor frame, then retighten the loose screw. Connect the positive lead from a 1.5 volt AA (or similar) battery to the ignition module’s “P” terminal (pickup coil terminal).
   c. With the key in the ON position, note the voltmeter reading. It must be battery voltage. If not, you didn’t verify the coil primary windings are good or you didn’t find the short to ground in the gray tach lead. If the voltage is OK, proceed.
   d. While observing the voltmeter, **momentarily** connect the negative lead of the 1.5 volt battery to the distributor frame. The voltage must drop several volts as the module grounds the negative side of the coil. If not, replace the ignition module.
   e. When the negative battery lead is disconnected from the distributor frame, the voltage must rise back to battery voltage and the ignition coil should fire. If the voltage changes, but the coil does not fire, replace the ignition coil (the secondary windings are open or shorted).
   f. When finished, reconnect all leads and connectors.

Non-Scan Diagnosis of Driveability Concerns (With No Codes Set)

If a driveability concern still exists after following the diagnostic circuit check and reviewing “Troubleshooting,” an out-of-range sensor may be suspected. Because of the unique design of the EFI system, fail-safes have been incorporated into the ECM to replace a sensed value with a default value in the case of a sensor malfunction or sensor wiring concern. By allowing this to occur, limited engine performance is restored until the vessel is repaired. A basic understanding of sensor operation is necessary in order to diagnose an out-of-range sensor.

If the sensor is within its working or acceptable parameters, as shown, (Figure A) the ECM does not detect a problem. If the sensor should happen to fall out of this “window,” a code will be stored. A known default value will replace the sensed value to restore engine performance.

If the sensor is out of range, but still within the operating window of the ECM, the problem will go undetected by the ECM and may result in a poor driveability condition.

A good example of this would be if the coolant (ECT) sensor was reading incorrectly and indicating to the ECM that coolant temperature was at 20° F, but actual coolant temperature was 175° F. (Figure B) This would cause the ECM to believe that the engine was running cold. The ECM would then control the fuel injectors to deliver more fuel than was actually needed and result in an overly rich, rough running condition. This condition would not have caused a code to set as the ECM interprets this as within its range.

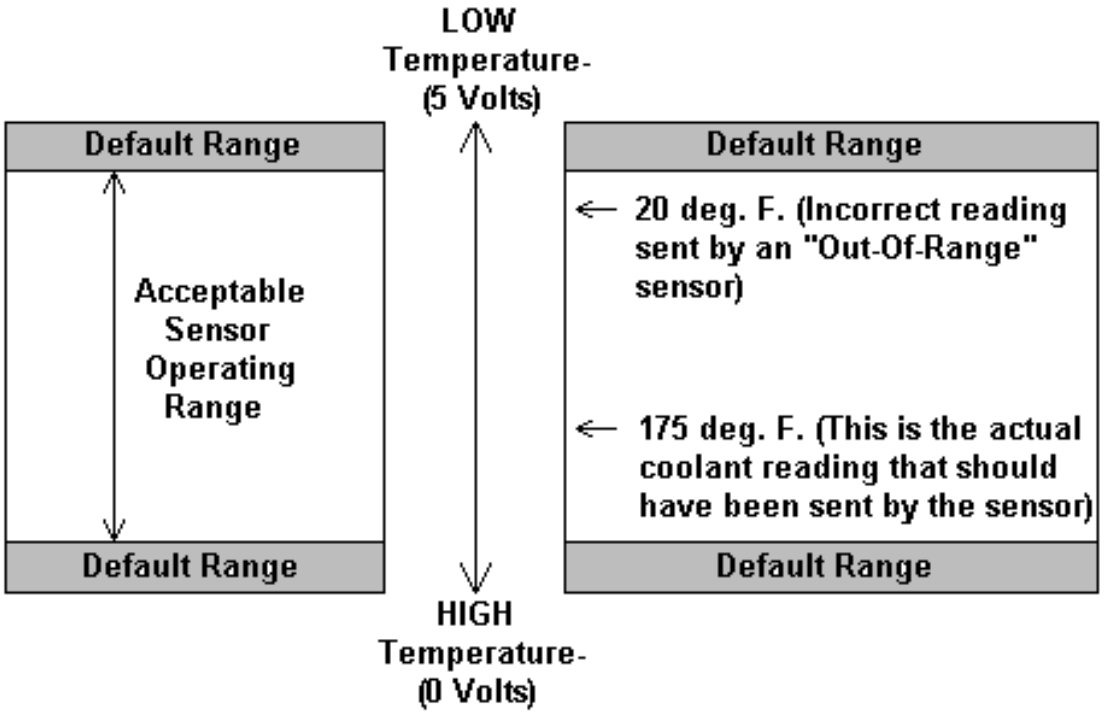


Figure A Figure B

To identify a sensor which is out of range, unplug it while running the engine. After approximately two minutes, the diagnostic code for that sensor will set a code, and replace the sensed value with a default value. If at that point a noticeable performance increase is observed, the diagnostic testing code chart for that particular sensor should be followed to correct the problem.

NOTE: *Be sure to clear each code after disconnecting and reconnecting each sensor. Failure to do so may result in a misdiagnosis of the problem.*

“Out-of-Range” Sensors

Scan Tool Use With Intermittents

The scan tool allows manipulation of wiring harnesses or components with the engine not running, while observing the scan tool readout.

The scan tool can be plugged in and observed while running the vessel under the condition when the Malfunction Indicator Lamp turns ON momentarily or when the engine driveability is momentarily poor. If the problem seems to be related to certain parameters that can be checked on the scan tool, they should be checked while running the vessel. If there does not seem to be any correlation between the problem and any specific circuit, the scan tool can be checked on each position, watching for a period of time to see if there is any change in the readings that indicates intermittent operation.

The scan tool is also an easy way to compare the operating parameters of a poorly operating engine with those of a known good one. For example, a sensor may shift in value but not set a trouble code. Comparing the senor’s readings with those of the typical scan tool data readings may uncover the problem.

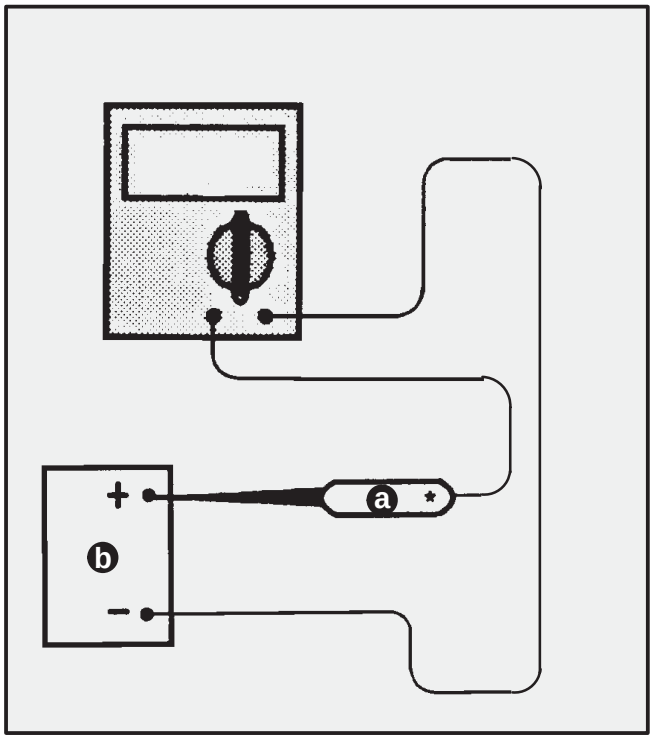
The scan tool has the ability to save time in diagnosis and prevent the replacement of good parts. The key to using the scan tool successfully for diagnosis lies in the technician’s ability to understand the system he is trying to diagnose as well as an understanding of the scan tool operation and limitations. The technician should read the tool manufacturer’s operating manual to become familiar with the tool’s operation.

General Service Precautions When Working On EFI Systems

The following requirements must be observed:

1. Before removing any ECM system component, disconnect the negative battery cable.
2. Never start the engine without the battery being solidly connected.
3. Never separate the battery from the on-board electrical system while the engine is running.
4. Never separate the battery feed wire from the charging system while the engine is running.
5. When charging the battery, disconnect it from the boat's electrical system.
6. Ensure that all cable harnesses are connected solidly and that battery connections are thoroughly clean.
7. Never connect or disconnect the wiring harness at the ECM when the ignition is switched ON.
8. Before attempting any electric arc welding, disconnect the battery leads and the ECM connector(s).
9. When steam cleaning engines, do not direct the steam cleaning nozzle at ECM system components. If this happens, corrosion of the terminals or damage of components can take place.
10. Use only the test equipment specified in the diagnostic charts, since other test equipment may either give incorrect results or damage good components.
11. All voltage measurements using a voltmeter require a digital voltmeter with a rating of 10 megohms input impedance.

12. When a test light is specified, a “low-power” test light must be used. DO NOT use a high-wattage test light. While a particular brand of test light is not suggested, a simple test, as shown below, on any test light will ensure it to be safe for system circuit testing. Connect an accurate ammeter (such as the high impedance digital multimeter) in series with the test light being tested, and power the test light ammeter circuit with the vehicle battery.



a - Test Light
b - Battery

IMPORTANT: If the ammeter indicates LESS than 3/10 amp. current flow (.3 A or 300 mA), the test light is SAFE to use.
If the ammeter indicates MORE than 3/10 amp. current flow (.3 A or 300 mA), the test light is NOT SAFE to use.

NOTE: *Using a test light with 100 mA or less rating may show a faint glow when test actually states no light.*

13. When using a DVOM to perform voltage measurements, turn the ignition OFF when connecting the DVOM to the circuitry to be tested.

Intermittent Faults

IMPORTANT: Problem may or may not turn “ON” the Malfunction Indicator Lamp (MIL) or store a DTC. DO NOT use the Diagnostic Trouble Code (DTC) tables for intermittent problems. The fault must be present to locate the problem.

Most intermittent problems are caused by faulty electrical connections or wiring. Perform careful visual/physical check. Check for the following conditions:

- Poor mating of the connector halves, or a terminal not fully seated in the connector body (backed out or loose).
- Improperly formed or damaged terminals and/or connectors.

All connector terminals in the problem circuit should be carefully checked for proper contact tension.

- Poor terminal to wire connection (crimping).This requires removing the terminal from the connector body to check. Refer to “Wiring Harness Service” in the “Description and System Operation” section.

The vessel may be driven with a Digital Multimeter connected to a suspected circuit. An abnormal voltage when malfunction occurs is a good indication that there is a fault in the circuit being monitored.

A scan tool (see “Special Tools” for part numbers) can be used to help detect intermittent conditions. The scan tools have several features that can be used to locate an intermittent condition. The following features can be used in finding an intermittent fault:

The “Record” feature or choosing not to erase data can be triggered to capture and store engine parameters within the scan tool when the malfunction occurs. This stored information can then be reviewed by the service technician to see what caused the malfunction.

To check loss of DTC memory, disconnect TP sensor and idle engine until the MIL comes “ON.” A trouble code should be stored and kept in memory when ignition is turned “OFF.” If not, the ECM is faulty. When this test is completed, make sure that you clear the DTC 22 from memory.

An intermittent MIL with no stored DTC may be caused by the following:

- Ignition coil shorted to ground and arcing at ignition wires or plugs.
- MIL wire to ECM shorted to ground.
- Poor ECM grounds, Go to ECM wiring diagrams.
- Check for an electrical system interference caused by a sharp electrical surge. Normally, the problem will occur when the faulty component is operated.
- Check for improper installation of electrical options such as lights, ship to shore radios, sonar, etc.
- Check that knock sensor wires are routed away from spark plug wires, ignition system components and charging system components.
- Check for secondary ignition components shorted to ground, or an open ignition coil ground (coil mounting brackets).
- Check for components internally shorted to ground such as starters, alternators or relays.

All Ignition Control (IC) module wiring should kept away from the alternator. Check all wires from the ECM to the ignition control module for poor connections.

EFI Troubleshooting Guide - MEFI Systems

Troubleshooting Flow Chart for MerCruiser EFI/MPI Engines (abbreviated)

A Diagnostic Trouble Code indicates that the ECM has sensed that the circuit in question has recorded a sensor value outside of its acceptable “window” for at least as long as its pre-programmed time period.

I. The process begins with a Customer Complaint or when the technician notes an “Observable Symptom”.
II. The technician must Verify (or Duplicate) the complaint (or symptom).
III. The technical must perform the OBD (On Board Diagnostic) check, which consists of three major steps:
   A. Verify scan tool link up (communication with ECM) or code 12 on the winky-blinky. If not, go to the appropriate chart in the service manual (usually Chart A-1 and/or A-2).
   B. Verify that the engine will start. If not, go to the “no-start” chart (usually Chart A-3). Note that the engine does not have to run correctly, it just must run.
   C. Check for Diagnostic Trouble Codes. If codes are present, fix active codes first (lowest number code to highest number code), then repair logged codes in same manner. Locate the code in the table of contents (of the appropriate service manual and section). The section is usually called “general system diagnostics” or just “diagnostics”.
      1. When troubleshooting active codes, the circuit in question is experiencing a failure **right now**. You are looking for an open circuit or short circuit in the 2 or 3 wires involved with the sensor in question, the sensor itself has actually failed or the connections at the ECM have failed. In one fashion or another, the troubleshooting chart will have you check each wire for continuity and shorts and test the sensor for correct operation.
      2. When troubleshooting logged codes, the circuit in question **is not** experiencing a failure at this time. You are looking for an intermittent connection or an intermittent short circuit that is not present right now. You must still check circuits for opens and shorts, but you must wiggle wires and connectors during all tests in attempt to locate the poor connection. Carefully look for subtle problems, such as corroded connections and internal wiring harness splices; and for connectors with a loose fit between the male and female pins.
      3. Codes rarely indicate a fault with the ECM. Assume that the ECM is working correctly until complete and thorough troubleshooting procedures prove otherwise.
IV. If no codes are present, but you still have an observable symptom, go to the “diagnosis by symptom” section, usually called “fuel injection system troubleshooting”. Match the observed symptom with the closest chart in the table of contents. Carefully follow the troubleshooting chart to test each suspect system or circuit. The problem may be that a sensor is “out of calibration” or it may be that the problem has nothing to do with the EFI system.
V. If there are no codes and no observable symptoms, then troubleshooting is finished.

EFI Troubleshooting Guide - MEFI Systems (cont.)

Visual/Physical Check:

I. Verify that the battery is fully charged and is of sufficient capacity for the engine being tested. If necessary, substitute a known good battery.

II. Check the battery cable connections. Make sure they are clean and tight. If present, discard wing nuts and replace with corrosion resistant hex nuts. A corrosion resistant toothed washer should be installed between the battery terminal and the cable end (stack up must be battery terminal, washer, cable, nut). Make sure the cable connections are tight at the starter solenoid and that the block fuse on the starter solenoid (if present) is tight and its' through bolt is not loose. Also make sure the ground stud is not loose in the engine block and that its' nut is tight.

III. If there is any doubt about the mechanical condition of the engine, perform a compression test.

IV. Make sure the safety lanyard is correctly installed and that the customer understands the correct starting procedure (clear flood mode).

V. Check that all grounds are clean and tight. If the negative battery cable is connected to the ground stud that does not contain all of the EFI and engine wiring harness ground leads, consider moving the negative battery cable to that ground stud.

VI. Check all vacuum lines for splits, kinks and proper connections. The fuel regulator on MPI models must be connected to manifold vacuum, while the fuel regulator on TBI models (cool fuel models) must be vented to atmospheric pressure (usually at the flame arrestor. The PCV valve used on newer models is a calibrated air leak, if it is missing or the incorrect valve is installed, engine operation will be effected.

VII. Check for any other additional air leaks in the induction system, such as throttle body and intake manifold gaskets. If the normal IAC counts for the engine are known, then any air leak will result in a lower IAC count than normal.

VIII. Unplug and inspect the ECM J-1 and J-2 connectors. Make sure there are no ECM pins bent over and that all of the correct pins are present. Refer to the service manual charts for the pins used and not used. Look for signs of tampering, corrosion, damage to the pin locking mechanisms, melted insulation and any other evidence of shorts or other damage.

IX. Unplug and inspect as many of the sensors and actuators as you can reasonably access. Look for signs of tampering, corrosion, damage to the pin locking mechanisms, melted insulation and any other evidence of shorts or other damage. Based on the results of this inspection, further inspection of the harness may be necessary. Remember that there are many internal splices in the harness that may be damaged or defective. If there is damage on the external connections, you will have to inspect several of the internal splices to verify that the damage is not also present at these locations.

X. Check for adequate secondary spark. If an air gap tester is used, make sure it will not ignite any fuel vapors that may be present in the bilge. A KV meter can also be used to check for adequate secondary voltage. Make sure the secondary wires are in good physical shape (correctly routed and that the boots are not split at either end). Remove the distributor cap and check for signs of moisture and carbon tracking.

   A. If there is no spark and the engine is equipped with Delco EST ignition, unplug the 4-pin connector at the distributor and recheck spark. If spark is still not present, the fault is isolated in the EST ignition system and is not an EFI system fault. With the 4-pin connector disconnected, this ignition can be diagnosed in the same manner as the 3.0 liter carbureted engine.

   B. If there is no spark and the engine is equipped with the Mercury Marine Thunderbolt distributor, refer to Service Bulletin 99-2 for troubleshooting procedures. These engines do not have a separate ignition module, instead they use the MEFI 3 ECM to control the ignition coil primary circuit.

EFI Troubleshooting Guide - MEFI Systems (cont.)

XI. Check for adequate fuel pressure at the throttle body or fuel rail.
   A. If there is no fuel pressure, check that the fuel pump is actually operating. The pump must run for at least 2 seconds each time the key is turned to the on position. If the fuel pump and the warning horn are not operating as the key is turned on, make sure the ECM is powering up (check the fuses and the system relay).
   B. On TBI models, the fuel pressure must be constant at all speeds and must be 30 psi +/– 2psi.
   C. On MPI models, the fuel pressure varies with engine vacuum. Fuel pressure will be high during cranking, low at idle and increase proportionally as the throttle is opened to the wide-open position. Disconnect the vacuum line to find the regulator's rated pressure, then reconnect the vacuum line to make sure the pressure drops at idle. Pressure specifications are 30, 36 or 43 psi (+/– 2psi) depending on model and year. Pressure usually drops about 6 psi at idle (from the regulator's rated specification). Refer to the service manual for specifications.
   D. If fuel pressure drops at higher speed and higher engine loads, check the boat's fuel system (the supply system) for restrictions with an accurate vacuum gauge and clear hose at the water separating fuel filter's inlet. As the engine is run from idle to wide open throttle and back to idle, the clear hose must not show the presence of any air bubbles and the vacuum gauge must not read higher than 2 in.-hg. Refer to Service Bulletin 99-7 for additional information.
   E. If the supply system tests ok, but the fuel pressure is low at high speeds and loads, replace the water separating fuel filter and retest. If pressure is still low, most likely the fuel pump is defective.

XII. Unplug and inspect the main harness (10 pin) connector between the engine and boat harnesses. If there is any doubt about the boat harness, substitute a shop harness and key switch assembly and rerun the boat. If the problem disappears, the problem is in the boat harness, not the MerCruiser engine harness. A suitable test harness can be assembled from the following components:
   A. MerCruiser 3 foot instrument harness cable – part number 84-812475A3
   B. MerCruiser ignition switch assembly – part number 54212A7
   C. Use suitable machine screws and nuts to join the switch's ring terminals to the harness's ring terminals, then cover the connections with heat shrink tubing.
   D. A standard piezo warning horn can also be added to provide audible warning of cooling system overheat, low crankcase oil pressure and low drive oil level (or high transmission temperature).

EFI Troubleshooting Guide - MEFI Systems (cont.)

Clearing Codes:

Codes are automatically erased after the engine has gone through its preprogrammed number of "power ups".

I. Scan tools:
   A. The Quicksilver DDT requires that the engine be running in order to clear the codes. If you attempt to clear the codes with the engine not running, the scan tool will attempt to clear the codes, but fail to actually accomplish it.
   B. The Rinda MerCruiser Scan tool can clear the codes with the engine running or with the engine in the "key-on, engine off" (KOEO) mode.

II. Codemate (winky-blinky):
   A. Clearing codes with the winky-blinky requires 2 separate procedures depending on whether you are working on a MEFI 1 system or a MEFI 2 or 3 system.
      1. **MEFI 1:** It is very difficult to clear codes on a MEFI 1 system because the engine must be cranked and started during the code clearing process. If the voltage at the ECM drops below 6.9 volts for even the briefest period of time, the ECM will "reset" and "forget" to clear the codes.
         a) Install winky-blinky to the DLC.
         b) Key On, Engine-Off (KOEO).
         c) Turn the winky-blinky to ON.
         d) While in Neutral, cycle the throttle from 0% to 100% and back to 0%.
         e) Turn the winky-blinky to OFF for at least 5 seconds.
         f) Turn the ignition key to OFF for at least 20 seconds.
         g) Start and run the engine for at least 20 seconds.
         h) Turn the ignition key to OFF for at least 20 seconds.
         i) Verify that the codes were erased.
      2. **MEFI 2 and 3:** Codes can be easily cleared on these models because the engine does not have to be started.
         a) Install winky-blinky to the DLC.
         b) Key On, Engine-Off (KOEO).
         c) Turn the winky-blinky to ON.
         d) While in Neutral, cycle the throttle form 0% to 100% and back to 0%.
         e) Turn the ignition key to OFF for at least 5 seconds.
         f) Verify that the codes were erased.

PCM/ECM 555 Diagnostics

A “Fault” indicates that the PCM/ECM555 has either sensed that the circuit in question has recorded a sensor value outside of its acceptable “window” or that a sensor value has gone outside its “normal” range. For example:

1. A circuit with an open or short would give a fault that is “CKT HI” or “CKT LO”. This means that the sensor itself has failed with an open or short circuit, or one of the leads between the sensor and the PCM/ECM is open or shorted. A “CKT HI” fault means that the PCM/ECM is seeing a 5.0 (or nearly 5) volt signal and a “CKT LO” fault means that the PCM/ECM is seeing a 0.0 (or nearly 0) volt signal.

2. A sensor showing a reading outside of its normal range, but not shorted or open, would give a fault identifying an abnormal operating condition, such as “ECT Coolant Overheat”, which means the ECT circuit is operating correctly, but the engine is simply overheating.

Abbreviated Procedure:

I. The process begins with a Customer Complaint or when the technician notes an “Observable Symptom”.
II. The technician must Verify (or Duplicate) the complaint (or symptom).
III. The technical should connect a scan tool and check for faults.
    A. If the fault is a CKT HI or CKT LO, refer to the wiring diagram and check each of the leads between the suspect sensor and the PCM/ECM for open and short circuits. The short circuit does not have to be to ground, it could be to any other wire in the harness. If the leads test good, then the sensor should be replaced.
        1. When troubleshooting active faults (faults displayed under the “Fault Status” screen), the circuit in question is experiencing a failure **right now**. You are looking for an open circuit or short circuit in the 2 or 3 wires involved with the sensor in question, the sensor itself has actually failed or the connections at the PCM/ECM have failed.
        2. When troubleshooting intermittent faults (faults displayed under the “Fault History” screens or faults that are NOT active in the “Fault Status” screen), the circuit in question **is not** experiencing a failure at this time. You are looking for an intermittent connection or an intermittent short circuit that is not present right now. You must still check circuits for opens and shorts, but you must wiggle wires and connectors during all tests in attempt to locate the poor connection. Carefully look for subtle problems, such as corroded connections and internal wiring harness splices; and for connectors with a loose fit between the male and female pins.
            a) An excellent way to find an intermittent problem is to use the data monitor function of the scan tool. While observing the data from the suspect circuit, wiggle the wires and connectors (of the suspect circuit) while the key is on or while the engine is running. When you locate the bad connection or broken/shorted lead, the data reading will fluctuate on the scan tool. Keep in mind that the refresh rate of the scan tool is relatively slow (every 50 milliseconds or so).
            b) The record (or min/max) function of the DMT 2000 (or equivalent) multimeter can also be used to monitor and record the voltage signals on the suspect circuit. Use the Rinda 94025 Jumper Lead Set (or equivalent) to connect the meter to the suspect sensor’s signal lead. Sensor signals must never be 0.0 or 5.0 volts. A multimeter can catch glitches as quick as a micro-second.

B. If the fault is an abnormal operating condition, repair the system as needed. For example, if the sea pump pressure is low, check the water pickups for obstructions, then replace the water pump impeller (and other parts as needed). Abnormal operating condition faults can be active or intermittent.
C. Faults rarely indicate a defective PCM/ECM. Assume that the PCM/ECM is working correctly until complete and thorough troubleshooting procedures prove otherwise.

IV. If no faults are present, but you still have an observable symptom, then the problem is with a component or system that the PCM/ECM cannot monitor. Carefully perform the Visual/Physical check (in the following section) and check for obvious things, such as incorrect fuel pressure, engine mechanical problems, exhaust blockage, etc.
A. The problem may be that a sensor is “out of calibration” or it may be that the problem has nothing to do with the EFI system (clogged fuel supply system, mechanical engine problems, etc.).
B. You can use the scan tool to fire the ignition coil(s) with or without the spark plugs installed. You can also use the scan tool to drop cylinders (while running) to do “power balance” tests. On PCM models, each cylinder’s injector can be dropped individually. On ECM models, each injector “bank” can be dropped individually.

V. If there are no faults and no observable symptoms, then troubleshooting is finished.

Visual/Physical Check:

I. Verify that the battery is fully charged and is of sufficient capacity for the engine being tested. If necessary, substitute a known good battery.
II. Check the battery cable connections. Make sure they are clean and tight. If present, discard wing nuts and replace with corrosion resistant hex nuts. A corrosion resistant toothed washer should be installed between the battery terminal and the cable end (stack up must be battery terminal, washer, cable, nut). Make sure the cable connections are tight at the starter solenoid and that the block fuse on the starter solenoid (if present) is tight and its’ through bolt is not loose. Also make sure the ground stud is not loose in the engine block and that its’ nut is tight.
III. If there is any doubt about the mechanical condition of the engine, perform a compression test.
IV. Make sure the safety lanyard is correctly installed and that the customer understands the correct starting procedure.
V. Check that all grounds are clean and tight. If the negative battery cable is connected to the ground stud that does not contain all of the EFI and engine wiring harness ground leads, consider moving the negative battery cable to that ground stud.
VI. Unplug and inspect the main harness (10 pin) connector between the engine and boat harnesses. If there is any doubt about the boat harness, substitute a shop harness and key switch assembly and rerun the boat. If the problem disappears, the problem is in the boat harness, not the MerCruiser engine harness. A suitable test harness can be assembled from the following components:
A. MerCruiser 3 foot instrument harness cable – part number 84-812475A3
B. MerCruiser ignition switch assembly – part number 54212A7
C. Use suitable machine screws and nuts to join the switch ring terminals to the harness’s ring terminals, then cover the connections with heat shrink tubing.
D. A standard piezo warning horn (such as 816492A6) can also be added to provide audible warning of cooling system overheat, low crankcase oil pressure and low drive oil level (or high transmission temperature).

PCM/ECM 555 Diagnostics (continued)

VII. Check for adequate fuel pressure at the fuel rail.
   A. If there is no fuel pressure, check that the fuel pump(s) is(are) actually operating. The pump(s) must run for at least 2 seconds each time the key is turned to the on position. If the fuel pump(s) and the warning horn are not operating as the key is turned on, make sure the PCM/ECM is powering up (check the fuses and the wake-up line).
   B. On PCM/ECM models, fuel pressure varies with engine vacuum. Fuel pressure will be high during cranking, low at idle and increase proportionally as the throttle is opened to the wide-open position. Disconnect the vacuum line (on the cool fuel regulator) to find the regulator's rated pressure, then reconnect the vacuum line to make sure the pressure drops at idle. Pressure specification is 43 psi (+/– 2 psi) on all models. Pressure usually drops about 6-8 psi at idle (from the regulator's rated specification).

NOTE: Remember that PCM (and some ECM) models use a boost pump that must maintain 7-9 psi at all speeds and loads. This means that the water separating fuel filter is also pressurized at 7-9 psi. All Boost pumps must use a "pre-filter", refer to Service Bulletin 2002-02 and 2002-03 for "pre-filter" information.

   C. If fuel pressure drops at higher speed and higher engine loads, check the boat's fuel system (the supply system) for restrictions with an accurate vacuum gauge and clear hose at the water separating fuel filter's inlet. As the engine is run from idle to wide open throttle and back to idle, the clear hose must not show the presence of any air bubbles and the vacuum gauge must not read higher than 2 in.-hg. Refer to Service Bulletin 99-7 for additional information.
   D. If the supply system tests ok, but the fuel pressure is low at high speeds and loads, replace the water separating fuel filter and retest. If pressure is still low, most likely the fuel pump is defective
   E. All PCM/ECM models use a "dummy" fuel pressure regulator on the fuel rail. This is not used on marine applications (but is a GM supplied part). The vacuum line attached to the "dummy" regulator is a possible vacuum leak and a possible fuel leak (if the "dummy" regulator's diaphragm should fail). Only the Cool Fuel regulator actually controls fuel rail pressure.

VIII. Check all vacuum lines for splits, kinks and proper connections. The fuel regulator on all PCM/ECM models must be connected to manifold vacuum. The PCV valve is a calibrated air leak, if it is missing or the incorrect valve is installed, engine operation will be effected.

IX. Check for any other additional air leaks in the induction system, such as throttle body and intake manifold gaskets. If the normal IAC % for the engine are known, then any air leak will result in a lower IAC % than normal.

X. Unplug and inspect the PCM/ECM A, B and C connectors. Make sure there are no PCM/ECM pins bent over and that all of the correct pins are present. Refer to the service manual charts for the pins used and not used. Look for signs of tampering, corrosion, damage to the pin locking mechanisms, melted insulation and any other evidence of shorts or other damage.

XI. Unplug and inspect as many of the sensors and actuators as you can reasonably access. Look for signs of tampering, corrosion, damage to the pin locking mechanisms, melted insulation and any other evidence of shorts or other damage. Based on the results of this inspection, further inspection of the harness may be necessary. Remember that there are many internal splices in the harness that may be damaged or defective. If there is damage on the external connections, you will have to inspect several of the internal splices to verify that the damage is not also present at these locations.

PCM/ECM 555 Diagnostics (continued)

XII. Check for adequate secondary spark. If an air gap tester is used, make sure it will not ignite any fuel vapors that may be present in the bilge. A KV meter can also be used to check for adequate secondary voltage. Make sure the secondary wires are in good physical shape (correctly routed and that the boots are not split at either end). Remove the distributor cap (ECM models) and check for signs of moisture and carbon tracking.

Clearing Codes:

Faults are cleared with a scan tool only. Refer to the appropriate DDT flow chart in the PCM/ECM Technician Guide for appropriate menus.

IMPORTANT NOTES:

1. When firing the ignition coil(s) under the "Auto Self Test" and "Output Load Test" screens:
   A. You must specify if the spark plugs are installed or not. If the spark plugs are installed, the PCM/ECM will fire the coil(s) at the minimum dwell time to prevent it from actually sparking in the combustion chamber (possibly igniting fuel vapors). If the spark plugs are not installed, the PCM/ECM will fire the coil(s) at the maximum dwell time to allow for visible spark. In either case, the PCM/ECM will monitor the 5 volt trigger circuits to attempt to detect whether the coil has "fired".

      NOTE: *If using an air gap tester (instead of a resistor-type spark plug), it may cause RFI that can result in the warning horn chirping or other unusual symptoms to occur.* ***DO NOT allow open spark to occur if fuel vapors might be present.***

   B. A PCM can individually fire each coil. An ECM only has one coil, so no matter what "cylinder" you attempt to activate, the same coil will fire in each case. However, the spark will attempt to go to wherever the rotor (in the distributor) is pointing. You must test at the coil lead or know where the rotor is pointing and install the test spark plug in that cylinders lead.
2. When performing the "Cylinder Misfire Test", the PCM/ECM will add extra fuel through the fuel injectors at idle and off-idle speeds, but will turn off the fuel injector(s) at higher speeds. The test is best performed under high-load/high-speed conditions. A PCM can individually control each fuel injector. An ECM engine fires the fuel injectors in banks. Bank #1 is 1,3 & 5 on a V6 and 1,4,6 & 7 on a V8. Bank #2 is 2, 4 & 6 on a V6 and 2,3,5 & 8 on a V8. Pressing number 1 activates "bank 1", while pressing number 2 activates "bank 2". Pressing any other number will result in an error message.

3. When firing the fuel injectors under the "Auto Self Test" and "Output Load Test" screens, the same rules apply as above. PMC fires individual injectors, ECM fires banks.

4. Timing is not adjustable on any PCM/ECM engine. The distributor on ECM engines only decides "where" the spark goes, not "when" it goes. Rotating the distributor from its properly "indexed" position will cause the spark to jump to the wrong tower in the distributor cap.

5. **IMPORTANT: On ECM555 engines, when the crankshaft is EXACTLY at #1 TDC compression, the distributor's rotor must EXACTLY align with the #6 (V6 engines) or #8 (V8 engines) cast into the distributor housing. If not, the spark will jump to the wrong "tower" in the distributor cap.**

PCM/ECM 555 Diagnostics (continued)

DTS Faults:

Faults relating to the ERC (electronic remote control) are only displayed on the System View (SC5000). There are 3 potentiometers in an ERC, 1 for shift control and 2 for throttle control, as well as switches for trim control, system view cursor control and other features.

Faults relating to the ETC (electronic throttle control) and the ESC (electronic shift control) are displayed on the DDT and the System View.

Two TPS sensors are integrated into the ETC. The ETC is replaced as an assembly and is not serviceable. There are 6 wires on an ETC. Sensor Power, Sensor Ground, TP1 signal, TP2 signal and 2 wires to run the servo motor.

The ESC contains one integrated sensor (like a TPS). The ESC is replaced as an assembly and is not serviceable. There are 5 wires on an ESC. Sensor Power, Sensor Ground, Sensor Signal and 2 wires to run the servo motor. A separate 2-wire Neutral Switch is used to cross-check the integrated sensor. The switch is located on the shift bracket (Bravo models) and is the Transmission's Neutral Safety switch on Inboard models.

DTS engines use a different PCM555 controller with a Motorola Base Part Number of 859611. Wiring diagrams are not in print at this time. Refer to the PCM/ECM spreadsheet showing the location, function and color-code of each PCM/ECM pin.

ECM 555 Troubleshooting Preliminary Checks

Several of the diagnostic procedures call for the completion of a Visual / Physical Checklist. The importance of this step cannot be stressed too strongly. It can lead to correcting a problem without further checks and can save valuable time. This check is outlined below:

Visual / Physical Checklist

Step	Action	Yes	No
1.	**Is the battery fully charged?**	Go to Step 2.	Recharge or replace battery. Restart checklist.
2.	**Are the battery cable connections clean and tight?**	Go to Step 3.	Clean or tighten battery cable connections. Go to Step 3.
3.	**Are the external engine grounds tight and clean?**	Go to Step 4.	Clean or tighten engine grounds. Go to Step 4.
4.	Check fuel line and fuel line connections for leaks, corrosion and blockage. **Was a problem found?**	Repair problem. Go to Step 5.	Go to Step 5.
5.	Check the 3 fuses located next to the ECM on the engine. **Are the fuses good?**	Go to Step 6.	Replace fuse. Go to Step 6.
6.	Check the 50 amp circuit breaker located on the engine to ensure that the circuit is closed. **Was the circuit breaker tripped?**	Reset the circuit breaker. Go to Step 7.	Go to Step 7.
7.	**Is the Lanyard Stop Switch in the wrong position?**	Toggle switch. Go to Step 8.	Go to Step 8.
8.	**Are you using the correct version of scan tool software for the engine in question?**	Go to OBD System Chart.	Obtain appropriate version of software. Go to OBD System Chart.

ECM 555 On-Board Diagnostic (OBD) System Chart

Step	Action	Yes	No
1.	**Was the Visual / Physical Checklist completed?**	Go to Step 2.	Go to Visual / Physical Checklist.
2.	Connect scan tool to the engine. Ignition ON. **Is the scan tool communicating with the ECM?**	Go to Step 10.	Go to Step 3.
3.	Ignition ON. Check for battery voltage (B+) at Pin 5 of the 10-pin connector coming from the helm. Ignition OFF. **With the ignition ON, was B+ present?**	Go to Step 4.	Locate and repair problem from the keyswitch to the engine ten pin connector. Re-test system.
4.	Ignition ON. Check for B+ at ECM Connector B-18. Ignition OFF. **With the ignition ON, was B+ present?**	Go to Step 6.	Go to Step 5.
5.	Check for continuity between Pin 5 of the 10-pin Connector of the engine harness and ECM Connector B-18. **Was continuity present?**	Go to Step 6.	Locate and repair the open in the harness. Re-test system.

ECM 555 On-Board Diagnostic (OBD) System Chart (continued)

6.	Ignition ON. Check for B+ at Diagnostic connector Pin D. Ignition OFF. **With the ignition ON, was B+ present?**	Go to Step 7.	Repair or replace harness. Re-test system.
7.	Check continuity of the ground wire, Diagnostic connector Pin A and Pin 1 of the 10-pin Connector. **Was continuity present?**	Go to Step 8.	Locate and repair the open in the harness. Re-test system.
8.	Check continuity between Diagnostic connector Pin B and ECM connector A-12. **Was continuity present?**	Go to Step 9.	Locate and repair the open in the harness. Re-test system.
9.	Check continuity between Diagnostic connector Pin C and ECM connector A-5. **Was continuity present?**	Replace ECM.	Locate and repair the open in the harness. Re-test system.
10.	Using the scan tool, check for faults stored in the ECM. **Were any faults present?**	Inspect and repair fault. Re-test system.	Go to appropriate symptom chart.

ECM 555 System Engine Fault Quick Reference Chart

This chart correlates with the fault list of the diagnostic tool. After displaying the faults stored in a ECM, the fault can be referenced on this chart for possible causes and checks to fix the problem. The single circuit diagrams in SECTION 3A correlate most of these faults with the sensor circuit schematics to help locate wiring problems.

Faults	Possible Causes	Action
1. ECT CKT Hi or Lo	**1.0** Open(Hi) or Short (Lo) in harness wiring, faulty connection	**1.0** Repair harness connection or cut in wire.
	1.1 Open(Hi) or Short (Lo) sensor	**1.1** Replace sensor.
	1.2 Water in the connector	**1.2** Dry connector and inspect for cracks or wear. Replace.
2. ECT Coolant Overheat	**2.0** Coolant leak	**2.0** Inspect closed cooling system.
	2.1 Restricted waterflow	**2.1** Check for blockage in inlet and outlet water hoses.
	2.2 Faulty seawater pump	**2.2** Inspect seawater pump water ports, impeller and seals for damage. Replace damaged parts.
	2.3 Faulty thermostat	**2.3** Replace thermostat.
	2.4 Faulty seawater pump	**2.4** Replace seawater pump.
	2.5 Worn or broken drive belt	**2.5** Replace drive belt.
3. EST 1 Open or Short	**3.0** Loose spark plug wire connection.	**3.0** Verify spark plug boot firmly connected.
	3.1 Broken spark plug	**3.1** Inspect spark plug for damage. Replace.
	3.2 Open or Short in harness wiring, bad harness connection	**3.2** Inspect coil harness. Repair or replace.
	3.3 Faulty coil	**3.3** Replace coil.
	3.4 Water in connection	**3.4** Dry connector and inspect for cracks or wear. Replace.
4. Fuel Injector 1-8 Open or Short	**4.0** Open or short in harness wire, bad harness connection or corroded terminals	**4.0** Inspect fuel injector harness. Repair or replace.
	4.1 Faulty fuel injector	**4.1** Replace fuel injector.
	4.2 12 volt fuel injector wire shorted to ground	**4.2** Inspect fuel injector harness. Repair or replace.
	4.3 Corroded harness terminals	**4.3** Inspect fuel injector harness. Repair or replace.

ECM 555 System Engine Fault Quick Reference Chart (cont.)

Faults	Possible Causes	Action
5. Guardian Strategy	**5.0** Engine block pressure, map sensor, oil pressure, starboard exhaust temperature, engine coolant temperature or overspeed readings are out of normal ranges	**5.0** Other fault codes will appear on the diagnostic tool. Verify repairs associated with the other faults. Scan for faults again.
6. IAC Output Lo or Hi	**6.0** Cut harness wire, bad harness connection, short in harness	**6.0** Inspect IAC wiring circuit. Repair.
	6.1 Faulty IAC, pindle stuck	**6.1** Replace IAC.
7. Knock Sensor 1 Hi or Lo	**7.0** Corrosion or wear on the sensor	**7.0** Replace sensor.
	7.1 Open or short in circuit	**7.1** Inspect harness. Repair or replace harness.
8. Low Drive Lube Strategy MCM engines only.	**8.0** Improper hose routing	**8.0** Route hose as shown in installation manual.
	8.1 Float in bottle stuck	**8.1** Replace bottle.
	8.2 Short in circuit	**8.2** Inspect circuit. Repair or replace harness.
	8.3 Incorrect gear lube level	**8.3** Fill drive lube monitor. Refer to appropriate service manual for filling instructions.
	8.4 System leak	**8.4** Inspect drive lube system. Repair or replace any worn parts.
9. Low Oil Pressure Strategy	**9.0** Faulty sensor readings	**9.0** Replace sensor with a known good sensor.
	9.1 Faulty oil pump	**9.1** Replace oil pump.
	9.2 Low oil level	**9.2** Check oil level**,** add oil.
10. Main Power Relay Output	**10.0** Short in MPR circuit	**10.0** Inspect MPR circuit. Repair or replace harness.
	10.1 Low battery voltage	**10.1** Charge battery or replace battery.
	10.2 Faulty MPR	**10.2** Replace MPR.
11. Main Power Relay Backfeed	**11.0** Driver power from some other source	**11.0** Test for voltage at 87 of the MPR with key OFF.
	11.1 Short in circuit at splice 105	**11.1** Inspect wiring harness. Repair or replace harness.

ECM 555 System Engine Fault Quick Reference Chart (cont.)

Faults	Possible Causes	Action
12. MAP Sensor 1 Input Hi or Lo	**12.0** Loose connection, corrosion, open (Lo) or short (Hi) in circuit	**12.0** Inspect circuit. Repair or replace harness.
	12.1 Faulty sensor	**12.1** Replace sensor.
13. MAT Sensor Hi or Lo	**13.0** Loose connection, corrosion, open (Lo) or short (Hi) in circuit	**13.0** Inspect circuit. Repair or replace harness.
	13.1 Faulty sensor	**13.1** Replace sensor.
14. Oil PSI CKT Hi or Lo	**14.0** Loose connection, corrosion, open (Lo) or short (Hi) in circuit	**14.0** Inspect circuit. Repair or replace harness.
	14.1 Faulty sensor	**14.1** Replace sensor.
15. Overspeed	**15.0** Underpropped	**15.0** Change propeller.
	15.1 Over trimmed condition	**15.1** Trim drive properly.
	15.2 Rev-limit out of range	**15.2** Check rev-limit.
16. Pitot CKT Hi or Lo	**16.0** Loose connection, open (Lo) or short (Hi) in wiring circuit	**16.0** Inspect wiring harness. Repair or replace harness.
	16.1 Corroded or faulty sensor	**16.1** Check sensor for damage. Replace seals or sensor.
	16.2 Loose hose connection	**16.2** Tighten hose connection.
17. seawater pump PSI Lo	**17.0** Restricted waterflow	**17.0** Check for blockage in inlet and outlet water hoses.
	17.1 Faulty seawater pump	**17.1** Inspect seawater pump water ports, impeller and seals for damage. Replace damaged parts.
	17.2 Faulty thermostat	**17.2** Replace thermostat.
	17.3 Faulty seawater pump	**17.3** Replace seawater pump.
	17.4 Worn or broken drive belt	**17.4** Replace drive belt.
18. seawater pump CKT Hi or Lo	**18.0** Loose connection, corrosion, open (Hi) or short (Lo) in circuit	**18.0** Inspect circuit. Repair or replace harness.
	18.1 Faulty sensor	**18.1** Replace sensor.

ECM 555 System Engine Fault Quick Reference Chart (cont.)

Faults	Possible Causes	Checks
19. Steer CKT Hi or Lo	**19.0** Loose connection, corrosion, open (Hi) or short (Lo) in circuit	**19.0** Inspect circuit. Repair or replace harness.
	19.1 Faulty sensor	**19.1** Replace sensor.
20. TPS1 CKT Hi or Lo	**20.0** Loose connection, corrosion, open (Lo) or short (Hi) in circuit	**20.0** Inspect circuit. Repair or replace harness.
	20.1 Faulty sensor	**20.1** Replace sensor.
21. TPS1 Range Hi or Lo	**21.0** Worn or damaged sensor, count reading over 990 for Hi, under 45 for Lo	**21.0** Inspect sensor for damage. Replace TPS.
	21.1 Short in transducer ground circuit	**21.1** Inspect harness for short to ground. Repair or replace harness.
	21.2 Worn, bent or corroded throttle lever	**21.2** Inspect throttle lever. Repair any damage.
22. Transmission Overtemp	**22.0** Loose connection, corrosion, open (Lo) or short (Hi) in circuit	**22.0** Inspect circuit. Repair or replace harness.
	22.1 Faulty sensor	**22.1** Inspect circuit. Repair or replace harness.
23. Trim CKT Hi or Lo	**23.0** Loose connection, corrosion, open (Lo) or short (Hi) in circuit	**23.0** Inspect circuit, repair or replace harness.
	23.1 Faulty sensor	**23.1** Replace sensor.
24. VDC PWR Lo	**24.0** Short to ground in the 5 volt system, harness or 3-wire sensor	**24.0** Read other faults for a starting point for finding the short. Repair or replace harness or faulty sensor.

NOTE: This is a preliminary copy and it is subject to change.

Gen III Cool Fuel Module Diagnostics

Models Affected

Application	Model	Serial Number
MCM	496 Mag	0W060000 and above
All Bravo	5.0L MPI	0W060000 and above
All Bravo	350 Mag MPI	0W060000 and above
All Bravo	6.2L MPI	0W060000 and above
MIE	8.1L (all)	0W090000 and above
MIE	350 Mag MPI	0W090000 and above
MIE	6.2L MPI	0W090000 and above

Situation

A new generation of the MerCruiser fuel cooling system has been developed and released into production. The Generation III Cool Fuel system incorporates many design elements. The following information is provided for maintenance and troubleshooting of the Generation III Cool Fuel Module. Upon completion of these tests, if problem exists, replace the complete Cool Fuel Module assembly.

Changing Water Separating Fuel Filter Element

⚠ WARNING

Avoid Fire or Explosion: The fuel injection system is pressurized during operation. Use care when removing the water separating fuel filter. Fuel could spray on the hot engine causing fire or explosion. Allow the engine to cool down before attempting to remove the water separating fuel filter in the following procedure.

⚠ WARNING

Be careful when changing the water separating fuel filter. Gasoline is extremely flammable and highly explosive under certain conditions. Ensure the ignition key is "OFF". Do not smoke or allow spark or open flame in the area when changing the fuel filter. Wipe up any spilled fuel immediately.

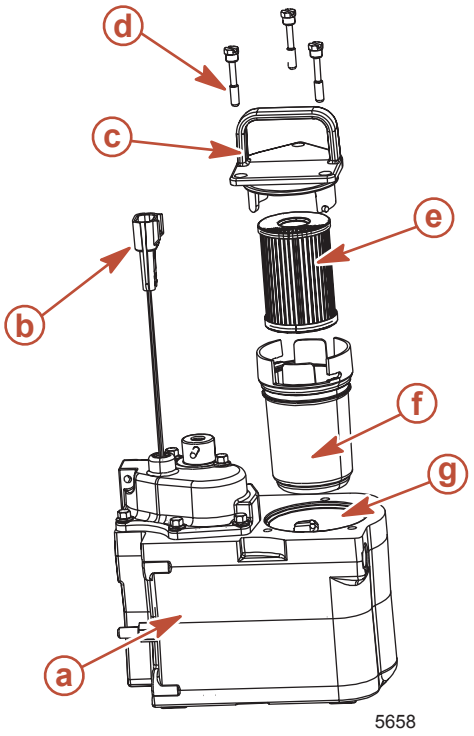
⚠ WARNING

Ensure that no fuel leaks exist before closing the engine hatch.

1. Allow the engine to cool down.

NOTE: *Mercury MerCruiser recommends that the engine be shut off for 12 hours prior to filter removal.*

2. Disconnect the Cool Fuel Module harness from the engine wiring harness.
3. Turn the key switch to the start position and allow the starter to operate for 5 seconds to relieve fuel system pressure.
4. Turn key switch to off position.
5. Loosen each filter assembly retaining screw until the screw is disengaged from the Cool Fuel Module. Do not remove the filter assembly retaining screws from the filter cap.



a - Cool Fuel Module
b - Cool Fuel Module harness
c - Filter cap and O-ring
d - Filter assembly retaining screw
e - Fuel filter element
f - Filter cap
g - Cool Fuel Module filter reservoir

6. Unseat filter assembly by grasping filter assembly handle and pulling upward. Do not remove the filter assembly from the Cool Fuel Module at this time.
7. Allow any fuel that may be in the filter assembly to drain out through the bottom of the filter assembly and into the Cool Fuel Module filter reservoir.
8. Remove the filter cup from the filter cap by grasping the filter cap and rotating it in a clockwise direction while holding the filter cup stationary.
9. Remove the used water separating fuel filter element from the filter cup, place it in a clean, approved container.

10. Dispose of any water or debris that may be in the filter cup.
11. Install a new water separating fuel filter element into the filter cup. Push the element into the cup until completely seated. Inspect O-ring in cap and replace if necessary.
12. Attach the filter cap to the filter cup by grasping the filter cap and rotating it in a counter clockwise direction while holding the filter cup stationary, until filter cap locks securely into place.
13. Install the fuel filter assembly slowly into the Cool Fuel Module to prevent spilling fuel, and align the screws retained in the filter cap with the screw holes in the Cool Fuel Module. Tighten the filter assembly retaining screws until hand tight.
14. Torque each filter assembly retaining screw.

Description	Nm	lb. in.	lb. ft.
Filter assembly retaining screw	4.5	40	

15. Reconnect the Cool Fuel Module harness to the engine wiring harness.
16. Supply cooling water to the engine.
17. Properly ventilate engine compartment.

⚠ WARNING

Avoid serious injury or death due to FIRE or EXPLOSION. Ensure that engine compartment is well ventilated and that no gasoline vapors are present to prevent the possibility of a FIRE or EXPLOSION.

⚠ WARNING

Ensure that no fuel leaks exist before closing the engine hatch.

18. Start the engine. Check for gasoline leaks around the fuel filter assembly. If leaks exist, stop the engine immediately. Recheck filter installation, clean spilled fuel and properly ventilate engine compartment. Correct the leak.

Electrical

1. Disconnect electrical connector at Cool Fuel Module.
2. Connect Digital Volt / Ohm Meter (DVOM) to engine side of electrical connector.
3. Turn ignition switch to run position.
4. Verify that there is 12 volt battery (+) power going to the Cool Fuel Module.

NOTE: *The fuel pump relay will only remain active for 2-3 seconds while the key is in the RUN position.*

Checking Fuel Pressure

1. Connect fuel pressure gauge to shrader valve on fuel rail.
2. Cycle key switch 2-3 times (OFF to RUN position) at 3 second intervals to reach maximum pressure.
3. Verify that the pressure is within specification.

4. If pressure is exceeds 44 psi:
   a. Replace Cool Fuel Module.
5. If pressure is equal to or less than 40 psi:
   a. Use a tee fitting and connect a vacuum gauge to the fuel inlet side of the Cool Fuel Module. Do not remove fuel inlet fitting adapter.
   b. Cycle key switch 2-3 times (OFF to RUN position) at 3 second intervals to reach maximum pressure.
   c. Verify that the vacuum from the fuel source is within specification. If vacuum is exceeds 2" Hg, excessive fuel restriction exists. Correct fuel restriction before proceeding.
   d. With vessel secured to the dock and engine running in neutral, restrict fuel supply and verify that the Cool Fuel Module has the ability to cause a vacuum reading of 11" Hg or greater. If vacuum reading is less than 11" Hg with fuel supply restricted, replace Cool Fuel Module.

In-Water Test

1. With vacuum gauge and fuel pressure gauges in place, run the boat underway throughout the RPM range and record the pressure and vacuum readings.
2. If fuel supply vacuum reading is greater than 2" Hg, find and correct fuel supply restriction.
3. If fuel supply vacuum is within specification and fuel pressure is less than 40 psi, replace Cool Fuel Module.

IMPORTANT: It will be necessary to sea-trial the boat following repairs to be sure that the pressure and fuel system vacuum remain within specification throughout the RPM range.

GENERAL INFORMATION

4

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Fuel Recommendations

IMPORTANT: Use of improper gasoline can damage your engine seriously. Engine damage resulting from use of improper gasoline is considered misuse of engine, and damage caused thereby will not be covered under the limited warranty.

FUEL RATINGS

USA and Canada - MerCruiser engines (with the exception of the early Black Scorpions [specified below]) in the USA and Canada will operate satisfactorily when using a major brand of unleaded gasoline having a MINIMUM pump posted Octane Rating of 87 AKI (anti knock index), which is the average of the RON (research octane number) and the MON (motor octane number).

Federal regulations mandate that you DO NOT use leaded gasoline in the USA and Canada.

Higher octane fuels can be used on all models with the exception of early EFI models. On early EFI models refer to Service Bulletin 94-12. If these engines are equipped with the original ECM, 87 AKI fuel must be used and higher octane fuels must NOT be used.

Early Black Scorpions – Black Scorpions with serial number 0L0058999 and below must use fuel with a 91 AKI minimum. Black Scorpions with serial number 0L0059000 and above can use fuel with a 87 AKI minimum.

Outside USA and Canada - MerCruiser engines (with the exception of the early Black Scorpions [specified below]) outside the USA and Canada will operate satisfactorily when using a major brand of unleaded gasoline having a MINIMUM research octane number (RON) of 90. The use of leaded gasoline is acceptable unless prohibited by government regulations.

Higher octane fuels can be used on all models with the exception of early EFI models. On early EFI models refer to Service Bulletin 94-12. If these engines are equipped with the original ECM, 90 RON fuel must be used and higher octane fuels must NOT be used.

Early Black Scorpions – Black Scorpions with serial number 0L0058999 and below must use fuel with a 98 RON minimum. Black Scorpions with serial number 0L0059000 and above can use fuel with a 90 RON minimum.

USING REFORMULATED (OXYGENATED) GASOLINES (USA ONLY)

This type of gasoline is required in certain areas of the USA. The two types of “oxygenates” used in these fuels is Alcohol (Ethanol) or Ether (MTBE or ETBE). If Ethanol is the “oxygenate” that is used in the gasoline in your area, refer to “Gasolines Containing Alcohol.”

These “Reformulated Gasolines” are acceptable for use in your MerCruiser engine.

GASOLINES CONTAINING ALCOHOL

If the gasoline in your area contains either “methanol” (methyl alcohol) or “ethanol” (ethyl alcohol), you should be aware of certain adverse effects that can occur. These adverse effects are more severe with “methanol.” Increasing the percentage of alcohol in the fuel can also worsen these adverse effects.

Some of these adverse effects are caused because the alcohol in the gasoline can absorb moisture from the air, resulting in a separation of the water/alcohol from the gasoline in the fuel tank.

The fuel system components on your MerCruiser engine will withstand up to 10% alcohol content in the gasoline. We do not know what percentage your boat’s fuel system will withstand. Contact your boat manufacturer for specific recommendations on the boats fuel system components (fuel tanks, fuel lines, and fittings). Be aware that gasolines containing alcohol may cause increased:

- Corrosion of metal parts.
- Deterioration of rubber or plastic parts.
- Fuel permeation through rubber fuel lines.
- Starting and operating difficulties.

⚠ WARNING

FIRE AND EXPLOSION HAZARD: Fuel leakage from any part of fuel system can be a fire and explosion hazard which can cause serious bodily injury or death. Careful periodic inspection of entire fuel system is mandatory, particularly after storage. All fuel components including fuel tanks, whether plastic metal or fiberglass, fuel lines, fittings, fuel filters and carburetors/fuel injection components should be inspected for leakage, softening, hardening, swelling or corrosion. Any sign of leakage or deterioration requires replacement before further engine operation.

Because of possible adverse effects of alcohol in gasoline, it is recommended that only alcohol-free gasoline be used where possible. If only fuel containing alcohol is available, or if the presence of alcohol is unknown, increased inspection frequency for leaks and abnormalities is required.

IMPORTANT: When operating a MerCruiser engine on gasoline containing alcohol, storage of gasoline in the fuel tank for long periods should be avoided. Long periods of storage, common to boats, create unique problems. In cars alcohol-blend fuels normally are consumed before they can absorb enough moisture to cause trouble, but boats often sit idle long enough for phase separation to take place. In addition, internal corrosion may take place during storage if alcohol has washed protective oil films from internal components.

Fuel Delivery System

⚠ WARNING

Boating standards (NMMA, ABYC, etc.) and Coast Guard regulations must be adhered to when constructing the engine compartment.

GENERAL

The main concern of a boat's fuel system is safety; this must be achieved through a technically sound installation and constant inspection.

The fuel system, from the filler pipe to the fuel pump, is the same in principle for all boats.

The fuel tank is an integrated component of the boat. Refer to the special information on service and maintenance, which you have received from the tank manufacturer.

Only a few points related to function and safety are listed here [Refer to boating standards (NMMA, ABYC, etc.) and Coast Guard regulations for complete guidelines]:

- All connections should be on the upper side of the tank.
- The drain plug at the lowest point on the tank serves to permit the removal of water and sediment.
- The filler pipe outer diameter should be at least 2 in. (50 mm).
- The tank breather pipe must have an inner diameter of at least 1/2 in. (13 mm) and must be fitted with a swan neck to prevent water from entering the tank.

It is recommended that the exact route and length of the fuel lines be established at the first installation of the engine to prevent problems later in connecting them to the engine.

All fuel lines must be well secured. The holes where the lines run through the bulkheads should be carefully rounded off or protected with rubber grommets. This prevents damage to the lines from abrasion.

The following, but not limited to the following, additional fuel connection related points, *applying to all engines unless otherwise stated*, must be considered [Refer to boating standards (NMMA, ABYC, etc.) and Coast Guard regulations for complete guidelines]:

1. **On Gasoline Engines:** Fuel tank should be mounted below carburetor level (if possible) or gravity feed may cause carburetor fuel inlet needle to unseat and flooding may result.
2. Fuel pickup should be at least 1 in. (25 mm) from the bottom of fuel tank to prevent picking up impurities.
3. **On Gasoline Engines:** The maximum measured vacuum at the engine's fuel inlet must not exceed 2 in. Hg or 1 psi (6.9 kPa) at 600, 3000, full throttle rpm, and idle rpm.

IMPORTANT: Vacuum reading higher than specified can cause vapor locking with some of today's fuels. It can also cause poor engine performance because of fuel starvation.

4. **On Gasoline Engines:** Fuel lines used must be Coast Guard approved (USCG Type A1).

Diameter of fittings and lines must not be smaller than 5/16 in. (8 mm) ID on 262 CID/4.3L and 305 CID/5.0L and 350 CID/5.7L engines.

Diameter of fittings and lines must not be smaller than 3/8 in. (10 mm) I.D. on 377 CID/6.2L, 454 CID/7.4L and 502 CID/8.2L engines.

5. **On Multi-Engine Gasoline Installations:** It is best to use a fuel pickup and supply line for **each** engine. If a single pickup and line is used, line must not be smaller than 1/2 in. (13mm) I.D.
6. Larger diameter (than previously specified) lines and fittings must be used on installations requiring long lines or numerous fittings.
7. Fuel line(s) should be installed free of stress and firmly secured to prevent vibration and/or chafing.

8. Sharp bends in fuel lines should be avoided.
9. A flexible fuel line must be used to connect fuel supply line to fuel inlet fitting on engine to absorb deflection when engine is running.

SPECIAL INFORMATION ABOUT ELECTRIC FUEL PUMPS

⚠ CAUTION

The electric fuel pump and factory installed water separating fuel filter have been carefully designed to function properly together. Do not install additional fuel filters and/or water separating fuel filters between fuel tank and engine.

The installation of additional filters may cause:

- Fuel Vapor Locking
- Difficult Warm-Starting
- Piston Detonation Due to Lean Fuel Mixture
- Poor Driveability

SPECIAL INFORMATION FOR ALL GASOLINE ENGINES

⚠ WARNING

Avoid gasoline fire or explosion. Gasoline is extremely flammable and highly explosive under certain conditions. NEVER use gasoline as a cleaning solvent.

IMPORTANT: The following information is provided to ensure proper installation of brass fittings or plugs installed into fuel pump or fuel filter base:

- **Use #592 Loctite Pipe Sealant with Teflon on threads of brass fittings or plugs. DO NOT USE TEFLON TAPE.**
- **Brass fittings or plugs should first be threaded into fuel pump or fuel filter base until finger tight.**
- **Fittings or plugs should then be tighten an additional 1-3/4 to 2-1/4 turns using a wrench. DO NOT OVERTIGHTEN.**
- **To prevent over-tightening when installing a fuel line, the brass fittings should be held with a suitable wrench as fuel line connectors are tightened securely.**

MERCURY MerCruiser service bulletin

No. 2001-15

☐ WARRANTY INFORMATION ☑ SERVICE INFORMATION

New Gasoline EFI/MPI Engine Fogging Procedure

Models

All MerCruiser gasoline EFI and MPI engines produced in Stillwater.

NOTE: *This change does not apply to carbureted engines produced in Stillwater or Hi-Performance engines produced by Mercury Racing.*

Change

Follow this new fogging procedure when laying an engine up for storage.

Fogging Mixture

In a 6 US gal (23 L) remote outboard fuel tank, mix:

5 US gal (19 L) regular unleaded 87 octane (90 RON) gasoline.

64 fl oz. (1.89 L) Mercury or Quicksilver Premium Plus 2-Cycle TC-W3 Outboard oil.

5 fl oz. (150 mL) Mercury or Quicksilver Fuel System Treatment and Stabilizer, OR 1 fl oz. (30 mL) Mercury or Quicksilver Fuel System Treatment and Stabilizer Concentrate.

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New Fogging Procedure

1. Disconnect and plug boat's fuel line from Water Separating Fuel Filter inlet.
2. Connect remote outboard fuel tank (with the fogging mixture) to the inlet of the Water Separating Fuel Filter.

IMPORTANT: If the boat is out of the water, follow instructions for running engine on flush device as found in service manual for the engine being fogged.

3. a. Cool Fuel models: Start and run engine at 1300 rpm for 5 minutes.
   b. VST models: Start and run engine at 1300 rpm for 10 minutes.
4. After specified running time is complete, slowly return throttle to idle rpm and shut engine off.

IMPORTANT: Do not run engine's fuel system dry of this fogging mixture in the 6 US gal (23 L) remote outboard fuel tank.

Battery Requirements for MerCruiser Products

Battery Ratings

There are two major rating systems used in the USA for marine engine cranking batteries. The most common is cca (cold cranking amps) which rates the cranking amps at 0° F. The second system, mca (marine cranking amps), rates the cranking amps at 32° F. The mca (marine cranking amps) rating of a given battery is always higher than the cca (cold cranking amps) rating. There is a third rating system that some discount stores use which rates the cranking amps of a battery at 80° F. The advertised cranking amps of these batteries is high while the actual cca of it is very low.

Cold Cranking Amps – (CCA)

This figure represents in amps the current flow the battery can deliver for 30 seconds at 0º Fahrenheit without dropping below 1.2 volts per cell (7.2 volts on a standard 12 volt battery). The higher the number, the more amps it can deliver to crank the engine. (CCA x 1.3 = MCA)

Marine Cranking Amps – (MCA)

This figure is similar to the CCA test figure except that the test is run at 32º Fahrenheit instead of “0”. (MCA x .77 = CCA)

This is more in line with actual boat operating conditions.

Reserve Capacity

This figure represents the time in minutes that a fully charged battery at 80º Fahrenheit can deliver 25 amps, without dropping below 1.75 volts per cell (10.5 volts on a standard 12 volt battery). The reserve capacity rating defines the length of time that a typical vehicle can be driven after the charging system fails. The 25 amp figure takes into account the power required by the ignition, lighting and other accessories. The higher the reserve capacity rating, the longer the vehicle could be driven after a charging system failure.

Amp-Hour Rating

The ampere hour rating method is also called the 20 hour rating method. This rating represents the steady current flow that the battery will deliver for 20 hours while at 80º Fahrenheit without dropping below 1.75 volts per cell (10.5 volts on a standard 12 volt battery). The rating is actually the steady current flow times the 20 hours. Example: A 60 amp-hour battery will deliver 3 amps continuously for 20 hours.

The following battery charts list the minimum cca, mca and Ah (Amp hour) ratings required for use on MerCruiser products. The Amp hour rating is used outside the USA and Canada.

GASOLINE ENGINES

Engine	CID (L)	Minimum Required Cranking Battery Size
4 4 V6 6 V8 V8 V8 Carb V8	153 (2.5) 181 (3.0) 229 (3.8) 250 (4.0) 302 (5.0) 305 (5.0) 350 (5.7) 351 (5.8)	375 cca or 475 mca or 90 Ah
4 V6 V8 V8 Carb	224 (3.7) 262 (4.3) 427 (7.0) 454 (7.4)	450 cca or 575 mca or 90 Ah
V8 V8 Carb V8	482 (7.9) 502 (8.2) 540 (8.9)	550 cca or 700 mca or 120 Ah
V8 Carb	572 (9.4)	600 cca or 750 mca or 150 Ah
All EFI and MPI Models		750 cca or 950 mca or 180 Ah

DIESEL ENGINES

Engine	CID (L)	Minimum Required Cranking Battery Size
4 4 5 6 6 V8	103 (1.7) 169 (2.8) 183 (3.0) 219 (3.6) 254 (4.2) 444 (7.3)	750 cca or 950 mca or 180 Ah

Battery Cables - Length and Size

NOTE: *Battery should be located as close to engine as possible.*

1. Select proper size positive (+) and negative (–) battery cables using the chart.
    1. Add the positive and negative cable lengths together.
    2. Divide by 2 to obtain the average cable length.

IMPORTANT: Terminals must be soldered to cable ends to ensure good electrical contact. Use electrical grade (resin flux) solder only. Do NOT use acid flux solder, as it may cause corrosion and a subsequent failure.

IMPORTANT: Tapered post connectors with wing nut connections can be used. The tapered posts must be used for the engine battery cables. The wing nut connections should be used only for the power trim pump and accessories. It is recommended that the wing nuts be replaced with regular nuts to ensure that the connections are tightened securely.

GASOLINE ENGINES

Battery Cable Length	Minimum Cable Gauge
Up to 3-1/2 ft. (1.1 m)	4 (25mm^2)
3-1/2 - 6 ft. (1.1 - 1.8 m)	2 (35mm^2)
6 - 7-1/2 ft. (1.8 - 2.3 m)	1 (50mm^2)
7-1/2 - 9-1/2 ft. (2.3 - 2.9 m)	0 (50mm^2)
9-1/2 - 12 ft. (2.9 - 3.7 m)	00 (70mm^2)
12 - 15 ft. (3.7 - 4.6 m)	000 (95mm^2)
15 - 19 ft. (4.6 - 5.8 m)	0000 (120mm^2)

DIESEL ENGINES

Battery Cable Length	Minimum Cable Gauge
Up to 3 ft. (0.9m)	2 (35mm^2)
3 - 3-3/4 ft. (0.9 - 1.1m)	1 (50mm^2)
3-3/4 - 4-3/4 ft. (1.1 - 1.4m)	0 (50mm^2)
4-3/4 - 6 ft. (1.4 - 1.8m)	00 (70mm^2)
6 - 7-1/2 ft. (1.8 - 2.3m)	000 (95mm^2)
7-1/2 - 9-1/2 ft. (2.3 - 2.9m)	0000 (120mm^2)
9-1/2 - 12 ft. (2.9 - 3.7m)	• 00 (70mm^2)
12 - 15 ft. (3.7 - 4.6m)	• 000 (95mm^2)
15 - 19 ft. (4.6 - 5.8m)	• 0000 (120mm^2)

- Two cables of specified gauge required for positive and two required for negative.

With the old battery cable recommendation, the negative (–) and the positive (+) battery cables were measured separately and then select the correct cable gauge to fit the length measured for each. This was OK if they were both the same length. It did not work well if there was a battery switch installed in the positive (+) battery cable between the engine and battery. Then, the positive (+) cable had to use a much larger gauge than the negative (–) did. In the example below, this would have meant the shorter 36 in. (91.4 cm) length negative (–) would have used a 4 ($25mm^2$) gauge cable. The longer 228 in. (579.1 cm) positive (+) cable would have used 0000 ($120mm^2$) gauge.

EXAMPLE: A person measures 36 in. (91.4 cm) length of negative (–) cable between engine and battery. They measure 108 in. (274.3 cm) of positive (+) cable between the engine and the battery switch and 120 in. (304.8 cm) between the battery switch and battery. Add 36 in. (91.4 cm) + 108 in. (274.3 cm) + 120 in. (304.8 cm) = 264 in. (670.5 cm) divide by 2 = 132 in. (335.3 cm) or 11 ft. (3.4 m). So BOTH the negative (–) AND positive (+) battery cable use the 00 ($70mm^2$) gauge cable.

By using the same gauge battery cable, 00 ($70mm^2$) gauge in the example above, for BOTH the negative (–) and positive (+) cable, the longer length positive (+) cable can use a smaller gauge cable than it would have if the negative (–) and positive (+) gauges were sized to their respective lengths.

Battery Testing

Hydrometer Tests:

A fully charged battery will read between 1.225 and 1.280 at 80º Fahrenheit. Readings of 1.225 and lower will require recharging & retesting. All cells should read within 30 points of each other. You must correct the Hydrometer reading for Ambient Temperature.

Capacity Tests:

(The Specific Gravity must be 1.225 or higher before continuing)

Variable Load High Rate Discharge Tester (Recommended): Discharge the battery with a load bank (carbon pile) set to 1/2 the CCA Rating or 3 times the Amp–Hour Rating for 15 Seconds, at the end of the 15 second period the battery voltage must be 9.6 volts or higher*.

Fixed Resistance: This equipment has built–in load for high–rate discharge testing. Follow equipment manufacturer's instructions regarding test period and meter readings.

Cranking Discharge Method: With a Voltmeter attached to the battery, Crank the engine for 15 seconds, the battery voltage must be 9.6 Volts or higher* at the end of the 15 second period.

* Lower ambient temperature readings (below 70º Fahrenheit) will result in lower voltage readings.

0ºF	10ºF	20ºF	30ºF	40ºF	50ºF	60ºF
8.5v	8.7v	8.9v	9.1v	9.3v	9.4v	9.5v

Charging Guide

12 Volt Battery Recommended Rate* and Time for Fully Discharged Condition

Twenty Hour Rating	5 Amperes	10 Amperes	20 Amperes	30 Amperes	40 Amperes	50 Amperes
50 Ampere-Hours or less	10 Hours	5 Hours	2-1/2 Hours	2 Hours		
Above 50 to 75 Ampere-Hours	15 Hours	7-1/2 Hours	3-1/2 Hours	2-1/2 Hours	2 Hours	1-1/2 Hours
Above 75 to 100 Ampere-Hours	20 Hours	10 Hours	5 Hours	3 Hours	2-1/2 Hours	2 Hours
Above 100 to 150 Ampere-Hours	30 Hours	15 Hours	7-1/2 Hours	5 Hours	3-1/2 Hours	3 Hours
Above 150 Ampere-Hours		20 Hours	10 Hours	6-1/2 Hours	5 Hours	4 Hours

* Initial rate for constant voltage taper rate charger

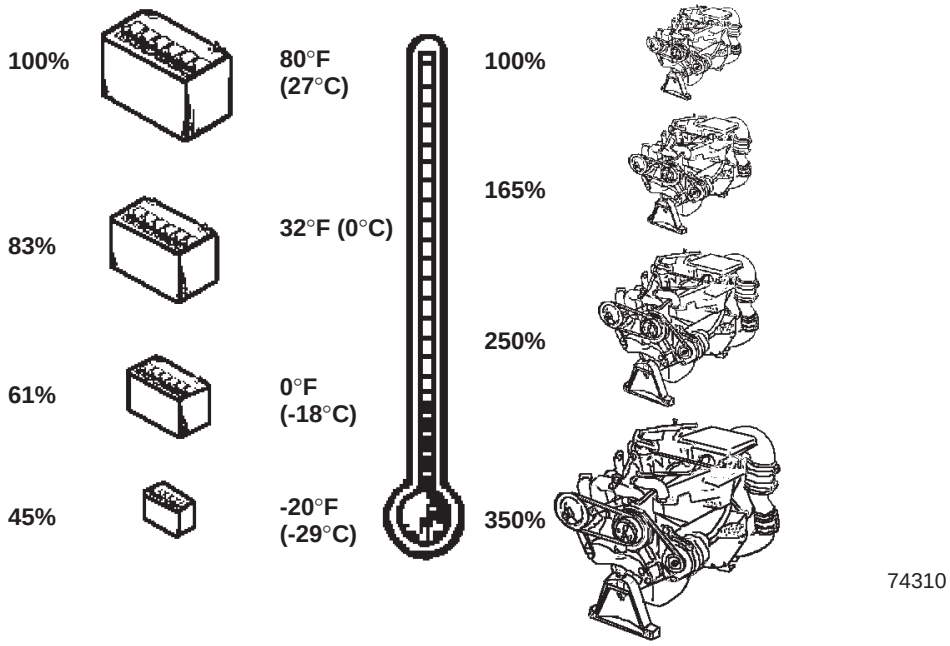
To avoid damage, charging rate must be reduced or temporarily halted, if:

1. Electrolyte temperature exceeds 125° F (52° C).
2. Violent gassing or spewing of electrolyte occurs.

Battery is fully charged when, over a two hour period at a low charging rate in amperes, all cells are gassing freely and no change in specific gravity occurs. For the most satisfactory charging, the lower charging rates in amperes are recommended.

Full charge specific gravity is 1.260-1.280, corrected for temperature with electrolyte level at split ring.

Battery Power as Affected by Temperature



Wiring Colors for MerCruiser

NOTE: *Color codes listed below DO NOT apply to fuel injection system harnesses.*

NMMA COLOR CODE AND ABBREVIATIONS	WHERE USED
BLACK (BLK)	All Grounds
BROWN (BRN)	Reference Electrode - MerCathode
LT. BLUE/WHITE (LT BLU/WHT)	Trim - “Up” Switch
GRAY (GRY)	Tachometer Signal
GREEN/WHITE (GRN/WHT)	Trim - “Down” Switch
TAN (TAN)	Water Temperature Sender to Gauge
LIGHT BLUE (LT BLU)	Oil Pressure Sender to Gauge
PINK (PNK)	Fuel Gauge Sender to Gauge
BROWN/WHITE (BRN/WHT)	Trim Sender to Trim Gauge
PURPLE/WHITE (PUR/WHT)	Trim - “Trailer” Switch
RED (RED)	Unprotected Wires from Battery
RED/PURPLE (RED/PUR)	Protected (Fused) Wires from Battery
RED/PURPLE (RED/PUR)	Protected (+12V) to Trim Panel
ORANGE (ORN)	Alternator Output / Anode Electrode - MerCathode
PURPLE/YELLOW (PUR/YEL)	Bypass-Ignition / Electric Fuel Pump*
PURPLE (PUR)	Ignition Switch (+12V)
YELLOW/RED (YEL/RED)	Starter Switch to Starter Solenoid to Neutral Start Switch
TAN/BLUE (TAN/BLU)	Audio Warning System

* Also Electric Chokes on models so equipped

NOTE: *Yellow used as GROUND wire in Europe and by some North American builders.*

NOTES:

Wiring Harness Service

Marine engine control circuits contain many special design features not found in standard land vehicle wiring. Environmental protection is used extensively to protect electrical contacts and proper splicing methods must be used.

The proper operation of low amperage input/output circuits depends upon good continuity between circuit connectors. Before component replacement and/or during normal troubleshooting procedures, visually inspect any questionable mating connector. Mating surfaces should be properly formed, clean and likely to make proper contact. Some typical causes of connector problems are listed below.

1. Improperly formed contacts and/or connector housing.
2. Damaged contacts or housing due to improper engagement.
3. Corrosion, sealer or other contaminants on the contact mating surfaces.
4. Incomplete mating of the connector halves during initial assembly or during subsequent troubleshooting procedures.
5. Tendency for connectors to come apart due to vibration and/or temperature cycling.
6. Terminals not fully seated in the connector body.
7. Inadequate terminal crimps to the wire.

Wire harnesses should be replaced with proper part number harnesses. When signal wires are spliced into a harness, use the same gauge wire with high temperature insulation only.

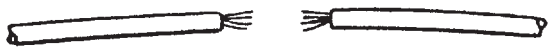
With the low current and voltage levels found in the system, it is important that the best possible bond be made at all wire splices by soldering the splices, as shown in the following illustrations. Use care when probing a connector or replacing connector terminals. It is possible to short between opposite terminals. If this happens, certain components can be damaged. Always use jumper wires with the corresponding mating terminals between connectors for circuit checking. **NEVER** probe through connector seals, wire insulation, secondary ignition wires, boots, nipples or covers.

Microscopic damage or holes will result in eventual water intrusion, corrosion and/or component or circuit failure.

Wire Repair

NOTE: *Warranty repairs normally require the installation of a new harness.*

1. Locate damaged wire.
2. Remove insulation as required.



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3. Splice two wires together using splice clips and rosin core solder.

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4. Cover splice with heat shrink sleeve to insulate from other wires.

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Wiring Connector Service

Most connectors in the engine compartment are protected against moisture and dirt that could create oxidation and deposits on the terminals. This protection is important because of the very low voltage and current levels found in the electronic system. The connectors have a lock which secures the male and female terminals together. A secondary lock holds the seal and terminal into the connector.

When diagnosing, open circuits are often difficult to locate by sight because oxidation or terminal misalignment are hidden by the connectors. Merely wiggling a connector on a sensor or in the wiring harness may locate the open circuit condition. This should always be considered when an open circuit or failed sensor is indicated. Intermittent problems may also be caused by oxidized or loose connections.

Before making a connector repair, be certain of the type of connector. Some connectors look similar but are serviced differently. Replacement connectors and terminals are listed in the Parts Catalog.

Ensure that the connector seals are not deformed or crushed when mating the connectors together.

NOTES: